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A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

REVS. 988-1351 VOL. 7, NO. 4 APRIL 1954

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APPLIED MECHANICS REVIEWS

VOL. 7, NO. 4 MARTIN GOLAND *Editor* APRIL 1954

PROGRESS OF THE PHYSICS OF SOLIDS

FREDERICK SEITZ

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THE study of crystalline solids has passed through three major stages of development since the dawn of science, and a fourth period seems to be drawing to its climax at about the time this is written. The four periods correspond to the development of the following topics: (1) Macroscopic symmetry properties; (2) lattice theory and lattice models; (3) application of atomic theory to the determination of properties of perfect crystals; and (4) development of the theory of nearly perfect crystals. Although the first three subjects are still of very great interest and are still the object of much research, the fourth is receiving most attention at the present time, first, because it is in a critical state of development, and second, because imperfections are responsible for many of the most interesting properties of crystals, particularly those of engineering importance.

A possible fifth topic, namely, that relating to the surface properties of crystals could be added to this list. It is still in its infancy but promises to become of major interest before many more years have passed.

By 1940, the investigators concerned with solids had a fairly clear understanding of the factors which influence the idealized properties of the perfect solid. The development of quantum mechanics in the interval from 1925 to 1930 was essential for this understanding, and the period from 1930 to 1940 saw the solving of many of the major mysteries such as those centering on the question of why some solids are insulators and others are metals.

It became clear during this period of development, however, that only a fraction of the properties of real materials could be understood by reference to the ideal models of solids. A complete understanding of the behavior of solids required the development of a science of imperfections. This topic has occupied major attention in the past decade and a half. Actually, the transition in interest from perfect to imperfect crystals was not a discontinuous one, for the imperfections in crystals had been of interest ever since the study of these materials became systematized. In fact, some of the important steps in the study of imperfect crystals were made in the period between 1905 and 1935. For example, the essence of our understanding of semiconductors extends back to work of Baedeker prior to World War I. Similarly, some appreciation of the importance of imperfections in determining the electrical properties of salts and the mechanical properties of metals was attained in the period from 1925 to 1940. It was characteristic of all of this work, however, that no systematic attempt was made to interrelate the imperfections which were introduced by various investigators in order to explain a particular phenomenon. Perhaps the greatest progress that has been made since 1940 is in the clarification of this important interrelation.

It is now recognized that the imperfection-determined properties of crystals can be understood in terms of six primary imperfections which form a closely related family. They not only modify the properties of the crystal when present individually and alone, but also have important influences upon one another, much as the fundamental particles of physics may interact with one another. The six imperfections are as follows:

LATTICE VIBRATIONAL WAVES

Such waves are generated when the crystal absorbs sound or when its temperature is raised from the absolute zero, so that the atoms of the lattice undergo thermal oscillation. The amplitudes of the possible waves are not continuous, as classical mechanics would suggest, but are limited to discrete or quantized values. The vibrational waves may interact with one another because the forces between atoms are not harmonic. This interaction explains the fact that heat diffuses through a crystal instead of moving with constant velocity. One of the very important effects of the interaction between thermally induced vibrational waves is the production of localized concentrations of vibrational energy, or thermal fluctuations, which may induce other changes.

VACANT LATTICE SITES AND INTERSTITIAL ATOMS

At any finite temperature the perfect lattice becomes the seat of disorder which has the effect of increasing the randomness required thermodynamically by increased temperature. One of the standard indications of such disorder is the production of lattice defects. The most simple of these are interstitial atoms and vacant lattice sites. These imperfections migrate about the crystal under the action of thermal fluctuations and permit the atoms of the bulk material to migrate. In this way the imperfections permit diffusion and electrolytic conductivity. Most diffusion in solids occurs with the aid of lattice defects.

FREE ELECTRONS AND HOLES

The ideally perfect insulator possesses neither free electrons nor holes. However, these carriers may be introduced in a number of ways. For example, they may be introduced by irradiating the crystal with light or with ionizing radiations, such as x rays, by applying a strong electric field which frees electrons from the atoms, by adding foreign atoms which release electrons to the lattice, or by heating the specimen so that thermal fluctuations supply the needed excitation energy. Insulators in which free carriers appear become electronic conductors. This conductivity is called photoconductivity if induced by light, breakdown conductivity if introduced by electric field, and impurity-induced semiconductivity if produced by impurities.

EXCITONS

A free electron and a hole exert a Coulomb attraction on one another which permits them to form bound states in which the pair of particles move together. Such states are called exciton states and represent one of the important means by which relatively large quanta of energy can be transmitted from atom to atom without the transfer of a charge. The bundles of energy are called excitons. Exciton migration appears to be exceedingly important in many aspects of photochemistry and related fields.

IMPURITY ATOMS

Impurity atoms occur in all crystals, frequently in spite of the best efforts to exclude them. In many cases they are added in carefully controlled amounts to impart special properties. For example, an insulator may be transformed into a semiconductor by adding impurities. In addition, impurities may impart special optical, electrolytic, or mechanical properties.

DISLOCATIONS

There is ample evidence that ordinary crystal lattices possess a type of disregistry which cannot be interpreted on the assumption that individual atoms are independently out of place, as when interstitial atoms or vacancies are formed. Instead, the evidence requires the assumption that a large number of atoms are dislocated in a closely correlated manner. These imperfections are termed dislocations. They were first introduced to explain the plastic properties of crystals, in particular the ductility of metals. It is now recognized, however, that they play an exceedingly important role in connection with essentially all properties of imperfect crystals.

Among the most important realizations of recent years has been appreciation of the strong interaction between the different imperfections and of the fact that they can actually generate one another under suitable conditions. For example, impurity atoms may bind dislocations and lower the ductility of crystals. Still further, moving dislocations may generate lattice imperfections such as vacant lattice sites and interstitial atoms. Conversely, vacant lattice sites produced by thermal fluctuations at high temperatures may condense to form dislocations at low temperatures.

It seems safe to say that during the next decade the major problems of solid-state science will center on obtaining a deeper understanding of the behavior of the six imperfections described here and their mutual interaction, regardless of the guise under which individual research programs are constituted. It may be anticipated that during this period the groundwork will be laid for deeper understanding of the surface properties of crystals—a topic which is still in its infancy.

Books Received for Review

BELGRANO, J. C., NIETO, A. L., and URCELAY, J. M., Tratado de nomografia, Madrid, Instituto Tecnico de la Construccion y del Cemento, 1953, xii + 387 pp. 125 ptas.

COCHRAN, W. G., Sampling techniques, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, xiv + 330 pp. $6.50.

COURANT, R., and HILBERT, D., Methods of mathematical physics. Vol. I, 1st English ed., New York, London, Interscience Publishers, xvi + 561 pp. $9.50.

DOOB, J. L., Stochastic processes, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, x + 654 pp. $10.

ECKERT, B., with cooperation of SCHNELL, E., Axialkompressoren und Radialkompressoren. Anwendung, Theorie, Berechnung, Berlin, Springer-Verlag, 1953, x + 441 pp., 426 figs., 6 tables. DM 73.50.

ERDÉLYI, A., MAGNUS, W., OBERHETTINGER, F., and TRICOMI, F. G., Higher transcendental functions. Vols. I, II (Bateman Manuscript Project), New York, McGraw-Hill Book Co., Inc., 1953, xxvi + 302 pp.; xviii + 396 pp. $6.50; $7.50.

ESCHMANN-HASBARGEN-WEIGAND, Die Wälzlagerpraxis. Handbuch für die Berechnung und Gestaltung von Lagerungen, München, R. Oldenbourg, 1953, xii + 372 pp., 396 figs.

FOCKEN, C. M., Dimensional methods and their applications, New York, St. Martin's Press; London, Edward Arnold & Co., 1954, viii + 224 pp. $6.

GIFFEN, E., and MURASZEW, A., The atomisation of liquid fuels, New York, John Wiley & Sons, Inc., 1953, x + 246 pp. $6.

MUSKHELISHVILI, N. I., Singular integral equations, 2nd ed. (translated from Russian by Radok, J. R. M.), Groningen, Holland, P. Noordhoff, Ltd., 1953, 447 pp. Fl 28.50.

MUSKHELISHVILI, N. I., Some basic problems of the mathematical theory of elasticity, 3rd revised ed. (translated from Russian by Radok, J. R. M.), Groningen, Holland, P. Noordhoff, Ltd., 1953, xxxi + 704 pp. Fl 38.

TRATHEN, R. H., Statics and strength of materials, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, x + 506 pp.

Letters to the Editor

988. Re AMR 6, Rev. 2233 (July 1953): N. H. Polakowski, Effect of residual stresses on yielding and strain-ageing of carbon steel.

Residual stresses of the type disputed by reviewer do exist in twisted bars and they cause axial expansion of the periphery layers when the core is drilled out [see Swift, H. W., *Engineering* **164**, 253–257, 1947]. Neither the arguments nor the conclusions of the paper in question need be affected by the residual shear stresses which co-exist in this particular case.

N. H. Polakowski, England

989. Re AMR 6, Rev. 2707 (Sept. 1953): F. J. Plantema, Forces on elastic airplanes under landing impact.

Review states that the author does not consider the elasticity of the airframe. Although the paper deals exclusively with the computation of forces in a rigid airplane, the computations were

made for the purpose of comparing them with earlier ones which do consider the elasticity of the airframe. This fact, which was overlooked by the reviewer, is mentioned in the Introduction of the report. In the Conclusions on p. 7 it is mentioned that, in the special case considered, the rigid-frame analysis overrates the impact forces at its first maximum by 20%.

W. Flügge, USA

990. **Re AMR 6, Rev. 3502 (November 1953): W. Dienemann, Calculation of the thermal boundary layer of the flow around bodies with constant variable wall temperature.**

The word "thermal" in line 8 of the above review should be replaced by "transverse-flow." C.-S. Yih, USA

991. **Re AMR 6, Rev. 3712 (December 1953): J. E. Goldberg, Stiffness charts for gusseted members under axial load.**

This paper was intended to present charts showing the effect of infinitely rigid gussets and axial load upon member stiffness, i.e., upon the slope deflection or moment-distribution constants. It was stated in the paper that if an actual gusset could be replaced by an equivalent infinitely rigid gusset, these charts could be used in truss analyses for secondary stresses or general instability. It was intended to leave open the question of how an actual gusset could be reduced to an equivalent infinitely rigid gusset, although it may be mentioned here that this could be done on the basis of tests or by semirational methods. In the paper an extremely simple method was suggested (not proposed) for reducing the actual gusset to an equivalent infinitely rigid gusset, and it was stated that this procedure might yield sufficiently accurate results under certain conditions. One has, furthermore, the option of using such a method in conjunction with overlapping or limiting assumptions. The paper was not concerned primarily with the matter of equivalent effective length, as the review seems to imply, but with the presentation of the charts which presuppose an acceptable method for finding the effective length. J. E. Goldberg, USA

Theoretical and Experimental Methods

(See also Revs. 1019, 1042, 1048, 1049, 1068, 1075, 1079, 1100, 1117, 1155, 1157, 1162, 1195, 1215, 1291, 1299)

992. **McLachlan, N. W., Complex variable theory and transform calculus with technical applications, 2nd ed.,** New York, Cambridge Univ. Press, 1953, xi + 388 pp. $10.

This is an excellent treatise for the student and applied worker. As author states in preface, much of the material in the first edition has been revised and made current. Certain old sections have been deleted and more important subject matter introduced. The sections on partial-differential equation have been recast so that attack is via Laplace transform.

Volume is in four parts. Part I takes up fundamental principles of complex variable. The Bromwich contour is introduced and applications to evaluation of integrals and higher mathematical functions are presented. Part II treats the transform calculus. In part III, reader will find applications to a wide variety of technical problems in dynamics, acoustics, heat, electric circuits, and many others. Part IV contains a number of appendixes giving proofs of theorems omitted in text itself. Here also are numerous examples illustrating subject which render volume a fitting text. A short list of p-multiplied Laplace transforms is given. A noteworthy feature is a bibliography including nearly 300 papers and books. Y. Luke, USA

993. **Jeffreys, H., On approximate solutions of linear differential equations,** *Proc. Camb. phil. Soc.* **49,** part 4, 601–611, Oct. 1953.

This paper is primarily concerned with the uniformity in a given interval of the first term of the asymptotic representation (in the Poincaré sense) of the solutions of the ordinary differential equation, $Y'' = (h^2 f_0 + h f_1 + f_2)Y$, where f_0, f_1, and f_2 are given functions of the independent variable and the parameter h is large. Conditions are given under which the first term of the representation is uniform within the given interval both when the variables are real or complex. In the case that f_0 possesses a simple zero in the interval, use of the Airy integral and its associated function Bi is suggested to simplify the procedure.

H. Yoshihara, USA

994. **Lotkin, M., A new integration procedure,** *J. Math. Phys.* **32,** 2–3, 171–179, July-Oct. 1953.

Paper extends method for integration of ordinary differential equations, developed in earlier paper [title source, **31,** p. 29, 1952], to the case where the functions are given in tabular form. Formulas given are suitable for use on high-speed calculating machines. Several examples are given.

Formulas differ from other quadrature formulas in (1) applying to the basic interval of length h so that quadratures over ranges of arbitrary length can be obtained simply, and (2) making use not only of interior and terminal points, but also of exterior points.

D. ter Haar, Scotland

995. **Washizu, K., Bounds for solutions of boundary value problems in elasticity,** *J. Math. Phys.* **32,** 2–3, 117–128, July-Oct. 1953.

Author uses method introduced by Diaz and Greenberg [AMR **2,** Rev. 306] to present a set of unified formulas for upper and lower bounds to solutions for two- and three-dimensional elasticity problems, bending of plates, and torsion of bars. These bounds, again, appear in terms of two auxiliary functions U, V. In all of the problems, except torsion of bars, U satisfies the differential equations of equilibrium and the stress conditions on the boundary, and V satisfies the compatibility relations and the displacement conditions on the boundary. A refinement of the upper and lower bounds presented requires the determination of certain complete sets of functions of which the author only notes the difficulty involved. From a point of view of practical application of the results, some information is needed in this direction.

M. Stippes, USA

996. **Collatz, L., Error estimation of iteration procedures for linear and nonlinear boundary-value problems** (in German), *ZAMM* **33,** 4, 116–127, Apr. 1953.

Author uses the fixed-point theorem and error-estimation procedure of J. Weissinger ["On the theory and application of the iteration method," *Math. Nachrichten* **8,** 193–212, 1952] to find error estimates for the iterates of the solutions of various classes of boundary-value problems solved by iteration procedures. In the nonlinear cases considered, the partial-differential equations have the highest-order derivatives appearing linearly and, in all cases, the boundary conditions are linear. The boundary-value problem is written in the iterative form $f = T[f]$ where the T operator satisfies a Lipschitz condition in a suitable Banach space. Many different types of normalizations are considered, and, in the illustrative examples, author demonstrates how important it is that the normalization be tailored to fit the specific problem in order that good error estimates are obtained.

P. Chiarulli, USA

997. **Popov, B. S., On Weber's differential equation,** *Proc. Indian Acad. Sci.* (*A*) **38,** 1, 64–66, July 1953.

998. **Ĕĭdus, D. M., Estimate of the modulus of eigenfunctions** (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **90,** 6, 973–974, June 1953.

Paper deals with eigenvalues λ_n and normalized characteristic functions u_n of the Helmholtz equation $\Delta u + \lambda u = 0$, in a finite region Ω of m-dimensional space and for zero values at the boundary Γ. In this case it is known that $|u_n| < c\lambda_n{}^k$, where $k = (m/4) + 1$ and c is constant.

Author establishes this inequality also for $k = m/4$ and, for arbitrary part Ω_0 of Ω, lying within Ω, he raises the exactness of the estimate, mentioned above, up to the value $k = (M - 1)/4$. In this case, however, the number c depends upon Ω_0.

Paper is of mathematical character, but the results have importance in the advanced theory of wave motion and in other fields of mathematical physics. V. Vodička, Czechoslovakia

999. **MacNeal, R. H., An asymmetrical finite difference network,** *Quart. appl. Math.* **11,** 3, 295–310, Oct. 1953.

Paper illustrates the well-known fact that a partial-difference equation may be given a physical meaning along any reference frame if the equations are transformed to a tensor-density form. In the new form the various quantities are changed from at-a-point values to line, surface, and volume integrals. The lines, surfaces, and volumes may assume any desired shapes in any combination. The illustrations in the paper refer to Poisson's equations represented by an arbitrary configuration of net points. In the tensor-density form the electrical circuits are shown to be capable of representing odd-shaped bodies with curved boundaries. The magnitudes of the errors are also investigated.

G. Kron, USA

1000. **Blanch, G., On the numerical solution of parabolic partial differential equations,** *J. Res. nat. Bur. Stands.* **50,** 6, 843–356, June 1953.

Study of the numerical solution of the differential equation $\partial u/\partial t = (\partial^2 u/\partial x^2) + f(x, t, u)$. The equation is approximated by a difference equation on a (t, x) lattice and the question of the mesh ratio most economical in work is investigated. This useful paper contains five numerical examples.

L. M. Milne-Thomson, England

1001. **Pipes, L. A., Matrix solution of equations of the Mathieu-Hill type,** *J. appl. Phys.* **24,** 7, 902–910, July 1953.

Let $A(t)$ be an $m \times m$ periodic matrix: $A(t + T) = A(t)$. Let $X(t)$ denote any (column) vector which satisfies the differential equation

$$\dot{x} = A(t)X \qquad [1]$$

($\cdot = d/dt$), and let $Y(t)$ be that $m \times m$ matrix which satisfies both [1] and the initial condition $Y(0) = I$, the unit matrix. Then, of course, $X(t) = Y(t)X(0)$. Paper is based on the well-known equations

$$X(nT) = [Y(T)]^n X(0)$$

$$X(nT + \tau) = Y(\tau)X(nT)$$

Tables are presented by whose use $[Y(T)]^n$ can be calculated for the case when $m = 2$ and $A(t)$ is of the form

$$A(t) = \begin{pmatrix} 0 & 1 \\ -F(t) & 0 \end{pmatrix}$$

Several examples are presented of the solution of differential equations by this method.

It should be noted that although the method offers certain computational simplifications when the solution is found for $t \geqslant T$, it depends nevertheless on the ability to solve the differential equation for $Y(t)$ in the interval $0 \leqslant t \leqslant T$. Therefore, any equation which can be solved using this method can also be solved without it. M. Shinbrot, USA

1002. **Alway, G. G., Automatic computing in aircraft engineering,** *Engineering* **176,** 4572, p. 351, Sept. 1953.

Paper presents a short discussion of the application of the digital machine at the National Physical Laboratory, the pilot A.C.E., to engineering design problems. This computer has been most successful in dealing with problems concerned with matrix algebra. Its capabilities in this field are given. Two programs for the solution of flutter problems on the pilot A.C.E. have been made so far. A brief description of these programs is presented. Emphasis is placed on two reasons for automatic digital computers becoming more powerful the more they are used. First, a library of subroutines is built up which facilitates the programming of new problems; and second, programmers continually improve the techniques for using their machine.

L. D. Findley, USA

1003. **Biermann, L., Billing, H., Hopmann, W., and Schlüter, A., The Gottigen electronic calculating machines I, II** (in German), *ZAMM* **33,** 1/2, 48–60, Jan./Feb. 1953.

Authors describe a general-purpose electronic automatically sequenced digital computer and compare it to other mathematical machines. The computer is controlled by a perforated paper tape and has a magnetic drum memory which rotates at 50 rps. It is a small computer containing less than 500 vacuum tubes and 100 relays. The computer has provision for cyclic interchange of numbers stored on the magnetic drum. Paper concludes with an example, which is the program for the numerical integration of a differential equation. C. L. Perry, USA

1004. **Anonymous, A general purpose electronic analogue computer,** *Engineer, Lond.* **196,** 5096, 395–397, Sept. 1953.

The electronic analog computer described is a general-purpose equipment designed for economical quantity production. It is a differential analyzer and its capacity is such that three similar computers coupled together should be capable of handling a general six-degrees-of-freedom problem. Some typical aircraft design applications are indicated in the article.

From article summary

1005. **Abramowitz, M., Evaluation of the integral** $\int_0^\infty e^{-u^2 - x/u} du$, *J. Math. Phys.* **32,** 2–3, 188–192, July-Oct. 1953.

The properties of this integral are described in terms of its differential equation, recursion formula, Laplace transforms, and asymptotic and series expansions for large and small x.

G. W. King, USA

1006. **Baron, M. L., and Bleich, H. H., Tables for frequencies and modes of free vibration of infinitely long thin cylindrical shells,** ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-33, 7 pp.

Paper gives tables of solutions to membrane (Rayleigh) equation for frequencies and mode shapes of title problem. Paper also gives correction factors based on energy method for effect of bending energy. These corrections are small for $R/t > 30$. Tables cover range $1 < L/R < 10$, $0 \leq n \leq 6$, and ν (Poisson's ratio) = 0.3. R. Plunkett, USA

1007. **Jackson, T. A. S., Rosenhead, L., and Murphy, T., Webb's approximation for sec θ,** *Engineering* **176,** 4571, p. 298, Sept. 1953.

A comparison of the approximation for sec θ has been made for values between 0 and $\pi/2$ taking it as $[1 + A \cdot 2\theta(\pi)]/[1 - (2\theta/\pi)^2]$ for three different values of A: (1) $A = 0.26$ given by Webb [see J. Case, "Strength of materials," p. 294]; (2) $A = 0.2337$ obtained by an expansion of sec θ in Maclaurin series; (3) $A = 0.2565$ obtained by least-squares method. Authors conclude that Webb's formula is correct to within $^1/_2\%$ error for values between 0 to $83^1/_2$ degrees and agrees to within two significant figures with least-squares method. D. N. Mitra, India

1008. **Lösch-Schoblik, Gamma and related functions [Die Fakultät (Gammafunktionen) und verwandte Funktionen],** Leipzig, B. G. Teubner Verlagsgesellschaft, 1951, vi + 205 pp. DM 16.80.

Volume deals with gamma and related functions in a suitable manner so as to provide a handbook for applied workers. For numerical applications it is designed for use in conjunction with the Jahnke-Emde tables. The related functions treated include the incomplete function, exponential, sin and cos integrals, error function, parabolic cylinder, and Whittaker functions. Applications to electrostatics, probability, heat, and others are presented. Though references are cited in text, a deficiency is the lack of bibliography which would aid reader to locate information not included in text. Y. Luke, USA

1009. **Natanson, I. P., Constructive theory of functions [Konstruktivnaya teoriya funktsii],** Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1949, 688 pp.

This work of the excellent Russian savant is one of the best and most complete of its kind. Being result of author's lectures conducted for a number of years at the Leningrad university, the book explains the theory of approximating real continuous functions by algebraic and trigonometric polynomials with real coefficients.

Three fundamentally different viewpoints on how to estimate degree of approximation of the given function $f(x)$ by a polynomial $P(x)$, divide the volume into three main parts. Using the maximum value of $f(x) - P(x)$ in the basic interval leads to theory of uniform approximations presented in the first section of the book (up to p. 284). Chiefly noted are, from technical standpoint, considerations on Fourier series, polynomials of Chebíshev and Bernstein, discussion of generalized summation methods of Fejér, Bernstein, Vallé-Poussin, and others.

Second main part (up to p. 490) deals with quadratic approximations having for criterion the value of the integral $\int [f(x) - P(x)]^2 dx$ over the associated interval. Engineers will get here information about systems of orthogonal functions and their special cases as polynomials of Legendre, Laguerre, L'Hermite, and Jacobi, which are of great significance in applied mathematics.

The last section (up to p. 663) presents a course of interpolation and mechanical quadrature. In this case, proximity of the given function $f(x)$ and polynomial $P(x)$ to each other is expressed by their equal values in certain points $x_1, x_2, \ldots, x_n$ of the fundamental interval (the well-known "knots of interpolation").

Then come three appendixes on Stirling's asymptotic formula for $n!$ and some special theorems by Muntz, Lozinskij, and Nikolajev. Book ends with a literature index and register.

This excellent work, intended mainly for mathematicians, is recommended also to engineers and physicists.

V. Vodička, Czechoslovakia

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1021, 1022, 1131, 1331)

1010. **Beyer, R., and Schörner, E., Foundations of spatial kinematics [Raumkinematische grundlagen],** München, Johann Ambrosius Barth, 1953, 104 pp., 33 figs. and 16 stereographs. DM 9.60.

This booklet succeeds admirably in presenting the subject with the aid of stereoscopic pictures (anaglyphs) viewed with red-and-blue spectacles. The pictured components of position vectors, velocity vectors, and acceleration vectors are correlated with their algebraic, analytic, and complex notations. The laws of addition and the measures of curvature and torsion are derived. The vector and scalar products are illustrated and applied in Euler's equation for angular velocity. The author's graphical construction for the moment vector is shown. It is demonstrated that every displacement of a rigid body can be represented as a helical displacement. The foregoing is applied to the resolution and balancing of forces in three-dimensional structures. Applications are made to the study of the motions and forces in a connecting rod joining two nonparallel cylindrical slides, bevel gears, helical gears, hypoid gears, and the swash-plate mechanism of variable stroke hydraulic pumps and motors. A selected bibliography of works on three-dimensional statics and kinematics is given. M. Goldberg, USA

1011. **Verkholat, M. E., Device for recording speed and acceleration of small, advancing movements** (in Russian), *Stanki i Instrument* no. 4, 3–7, 1953.

To investigate the course of working processes on lathes, an inductive transmitter has been developed, consisting, in principle, of a movable coil in the field of two permanent magnets of the horseshoe type or of the ring type. The induced emf proportional to the velocity of the coil relative to the magnets, is amplified in a three-stage electronic direct-current amplifier. The amplifier has outputs for velocity and acceleration. A detailed description of the amplifier and the stabilized power supply is given and examples of measurements are discussed.

W. Wuest, Germany

1012. **Shapiro, H., and Hudson, D. E., The measurement of acceleration pulses with the multifrequency reed gage,** *J. appl. Mech.* **20,** 3, 422–426, Sept. 1953.

Authors outline fundamental techniques of using multifrequency reed gages for measuring acceleration pulses.

Analog-computer results are obtained for a "standard" pulse consisting of a positive slope quarter sine wave, followed by an approximately linear negative slope region. Response curves indicate that adequate peak-reading accuracy may be obtained if the ratio of 2 (*pulse rise time*)/(*reed natural frequency*) is greater than 3. Damping improves the accuracy at high reed frequencies but at a sacrifice in resolution. A more concise treatment of accelerometer theory may be found in Den Hartog, "Mechanical vibrations," chap. II. G. S. Cherniak, USA

1013. **Gough, V. E., A simple direct-reading friction meter,** *J. sci. Instrum.* **30,** 10, 345–349, Oct. 1953.

The need for a direct-reading friction meter is discussed and the principles of a simple solution to the problem described. The basic mechanism is a platform carried by four identical levers each with a counterweight, and the whole system is in neutral equilibrium. All pivots are of low friction and the levers are arranged so that they are parallel at all angles and, in operation, all take up a direction parallel to the direction of the resultant reaction

between the two surfaces under test, one of which is the platform. The coefficient of friction is the tangent of the angle between the levers and the vertical. Some experimental findings on rubberlike materials are mentioned; these include the importance of the state of the surface. The maximum coefficient is not obtained at rest with rubberlike materials but arises when a slow sliding is taking place. A "squeal" often accompanies this high coefficient. Attention is directed to the need for statistically planned investigations when information is required as a basis for action. An appendix outlines the history of the development of the device.

From author's summary

1014. Howell, H. G., The general case of friction of a string around a cylinder, *J. Text. Inst. Trans.* **44,** 8/9, T359–T362, Aug./Sept. 1953.

The generalized friction law $F = \alpha R^n$ is applied to the problem of a string round a cylinder. It is shown that instead of the relation $T = T_0 \exp(\mu\theta)$, the expression obtained is $T^m = T_0^m + c$, where $m = 1 - n$. The theory is applied to the experimental results of Martin and Mittelmann [title source, **37,** T269, 1946] and good agreement is obtained. H. Kolsky, England

1015. Archard, J. F., Contact and rubbing of flat surfaces, *J. appl. Phys.* **24,** 8, 981–988, Aug. 1953.

Calculations are given for the conductivity and area of contact of a sphere or collection of spheres at various distances from the plane which come into contact with an invariable plane as the load increases. Both elastic and plastic deformations are considered. It is concluded that the most realistic approach is one for which increasing load increases both the number and size of the contact areas. This model is used to discuss wear, and it is concluded that agreement with experiment is best obtained when the deformation is plastic and the wear occurs by lumps being pulled out of the worn material. In obtaining this result it is not necessary to assume that the average size of the contact areas or wear particles is constant. W. P. Mason, USA

1016. Howell, H. G., The laws of static friction, *Textile Res. J.* **23,** 8, 589–591, Aug. 1953.

1017. Bondi, H., and Lyttleton, R. A., On the dynamical theory of the rotation of the earth. II. The effect of precession on the motion of the liquid core, *Proc. Camb. phil. Soc.* **49,** part 3, 498–515, July 1953.

In this part of their paper [for part I, see title source, **44,** 345–359, 1948; AMR **2,** Rev. 811], the authors attempt to determine the motion of a viscous liquid core of a planet on linearizing the general equations. The investigation suggests that the internal movements affected by the precession of a rigid shell cannot correspond to a steady state. Despite the simplifications (spherical cavity, uniform density of an incompressible liquid, very small angular velocity of precession) the linearized equations for the small departure from the rigid-body rotation remain extremely complicated. On discussing the motion in the boundary layer and also in a deeper internal region of the core, Bondi and Lyttleton show some difficulties connected with the boundary conditions. They derive a particular form of solution for the boundary layer representing the changes in velocity components across the depth of the layer. Doubt is voiced by the authors concerning the possibility of an internal motion which could be represented everywhere by analytic functions. It seems that the precessional motion of the earth should result in turbulence in the core. The main turbulence (in latitudes 30°N and 30°S) would introduce couples acting on the shell.

The approach in this paper does not follow the lines of some other investigations concerning the problem. See, for example, the discussion in Stekloff, *Ann. Fac. Sci. Univ. Toulouse* (3) **1,** 145–256, 1909, a paper which is also not mentioned in Lamb's "Hydrodynamics," 6th ed., Cambridge, 1932.

W. S. Jardetzky, USA

Gyroscopics, Governors, Servos

(See Revs. 1161, 1217)

Vibrations, Balancing

(See also Revs. 1006, 1223, 1224, 1225, 1226, 1301, 1308, 1310, 1313)

1018. Cochardt, A. W., A method for determining the internal damping of machine members, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-44, 6 pp.

A method is described for computing the total damping and resonance amplification factor for a part, having basic data on (a) the relationship between damping and stress and (b) the stress distribution of the part. The approach used is a general one applicable even to complicated damping-stress and stress-distribution functions. The results presented indicate that if a simple exponential type of relationship between stress and damping is assumed for a material with large magneto-mechanical damping, then a large error can result in computing the resonance amplification factor in a part (like a turbine blade) having relatively little percentage of volume at near maximum stress.

B. J. Lazan, USA

1019. Stoker, J. J., Periodic oscillations of nonlinear systems with infinitely many degrees of freedom (French and English), *Publ. sci. tech. Min. Air. Paris* no. 281, 61–74, 1953.

Author first outlines the theory of Poincaré for periodic solutions for systems having finite number of degrees of freedom. Some "degenerate" cases in which the Poincaré conditions are violated are discussed (Duffing and van der Pol equations). The problem of an elastically restrained vibrating string is then formulated as the wave equation plus a nonlinear term. Author then discusses conditions for periodic solutions and finds that an analogy exists between this problem and the Poincaré analysis for systems of a finite number of degrees of freedom. By assuming the nonlinear term in the problem formulated to be a cubic (after Duffing), an iteration procedure similar to the Duffing method is applied and the amplitude-frequency relation is determined.

Author states that present paper is of a "preliminary character"; therefore we may expect additional developments to be forthcoming. Reviewer also recommends paper by Grammel [AMR **6,** Rev. 2681]. H. N. Abramson, USA

1020. Muller, H., On the nonlinear theory of the vibrating string (in German), *Ann. Phys., Leipzig* **12,** 7–8, 398–400, Sept. 1953.

Author extends Kirchhoff's nonlinear theory of a vibrating string by considering finite displacements in the kinematic terms, whereas Kirchhoff considered nonlinear terms only in so far as they increase the tension of the string. Two simultaneous differential equations are set up, expressing the displacements of a particle perpendicular and parallel to the direction of the undisplaced string as functions of time and of original distance along the undisplaced string. No solutions are found.

F. R. N. Nabarro, South Africa

1021. **Satterly, J., Rocking experiment with two degrees of freedom,** *Amer. J. Phys.* **21,** 4, 267–273, Apr. 1953.

Study of oscillations of a system consisting of a cylinder within a ring, both with axes horizontal, on a horizontal table; ring and cylinder have opposed motion. Theoretical solutions for motion of two-degree-of-freedom system by use of Lagrangian equations are compared with experimental results for thin, thick, complete, and semicircular rings and hollow and solid cylinders of different sizes, with good agreement. M. D. Schwartz, USA

1022. **McDaniel, B. D., An experiment in mechanical resonance vibrations,** *Amer. J. Phys.* **21,** 7, 551–555, Oct. 1953.

An apparatus suitable for an elementary laboratory experiment on mechanical, forced, damped oscillations is described. Sample results with this apparatus show four ways of measuring Q and three ways of measuring the resonance frequency of the system, with good agreement among the results.

From author's summary

1023. **van Itterbeek, A., and Myncke, H., Vibration of plates covered with a damping layer,** *Acustica* **3,** 4, 207–212, 1953.

A study is made of the damping of steel plates covered with a thin layer of bitumen emulsion containing schist powder or similar products. This damping is characterized by the constant τ which is the time corresponding to a decrease of the amplitude of the vibration to one half. After a description of the experimental setup, results obtained with plates of various thicknesses and covered with different materials are given. The damping as a function of temperature, between -20 C and $+80$ C, is also determined. The check of the efficiency of the damping paint on a cement mill is also discussed. From authors' summary

1024. **Anderson, R. A., Flexural vibrations in uniform beams according to the Timoshenko theory,** *J. appl. Mech.* **20,** 4, 504–510, Dec. 1953.

See AMR **6,** Rev. 2998.

1025. **Kohn, P., Modification of Rayleigh's method for determining critical speeds of stepped shafts, simply supported on two bearings and with multiple load,** *Engng. Rev., Prague* no. 8, 25–30, Apr. 1951.

A new, approximate, algebraic method is presented for the determination of the critical speeds of shafts of variable cross section. Method serves to modify, for stepped shafts, either the Rayleigh or the Rayleigh-Ritz method and utilizes a conjugate shaft with identical mass distribution but constant moment of inertia.

Two examples are given and the results obtained by this and other methods are compared. New method is said to be limited to statically determinate problems in bending and to be faster, more accurate and adaptable than the commonly used graphical methods. E. W. Suppiger, USA

Wave Motion, Impact

(See also Revs. 998, 1035, 1093, 1253, 1254, 1255, 1338, 1341)

1026. **Miklowitz, J., Flexural wave solutions of coupled equations representing the more exact theory of bending,** *J. appl. Mech.* **20,** 4, 511–514, Dec. 1953.

Paper presents a new method for deriving flexural wave solutions for the Timoshenko bending theory. The method is based on a breakdown of the total deflection into its bending and shear components. Instead of treating the full Timoshenko equation [S. Timoshenko, "Vibration problems in engineering," New York, D. Van Nostrand Co., p. 338, 1937], an equivalent set of coupled equations, representing the rotational and translatory motions of the beam element, is solved. The advantages of this method stem from (a) the simplicity of the associated expressions for the moment and shear force, which are the elementary bending theory relations, and (b) the well-defined nature of the related boundary conditions. The latter is particularly important since it is difficult to define the proper boundary conditions associated with the full Timoshenko equation. This is evidenced in the works of Uflyand [AMR **3,** Rev. 33] and Dengler and Goland [AMR **6,** Rev. 2703], both of which are concerned with wave solutions for the infinite beam under the action of a concentrated transverse load. The last quoted work points out the erroneous boundary conditions used in the Uflyand work. The present method is applied to the same case treated in the works by Uflyand, and Dengler and Goland. Agreement is shown with the Dengler and Goland solution. The Uflyand solution is shown to have meaning when interpreted properly. The derivation of transforms for other beam cases, both finite and infinite, by the present method is also included in this work.

From author's summary by J. L. Lubkin, USA

1027. **Mintzer, D., Wave propagation in a randomly inhomogeneous medium. I,** *J. acoust. Soc. Amer.* **25,** 5, 922–927, Sept. 1953.

Author considers the propagation of sound pulses in a medium whose index of refraction has a mean value unity but which has small random variations about this mean. The sound pulses are assumed to be emitted from a point source. Using the Born approximation to the wave equation, author calculates the coefficient of variation (standard deviation of the amplitude of a series of pulses, expressed as a percentage of the mean amplitude of the series) for pulses of duration small in comparison with the time during which the index of refraction varies, and for ranges greatly in excess of the wave length of the sound. This quantity is expressed in a form which can be applied to experimental data of M. J. Sheehy [AMR **4,** Rev. 3066], which showed that the pressure fluctuation for deep-water transmission increases with increasing range for directly received signals. It is found that a small range of the relevant theoretical parameters suffices to fit the experimental data. I. N. Sneddon, England

1028. **Sternglass, E. J., and Stuart, D. A., An experimental study of the propagation of transient longitudinal deformations in elastoplastic media,** *J. appl. Mech.* **20,** 3, 427–434, Sept. 1953.

The propagation process of longitudinal plastic pulses in prestrained bars has been studied to test the validity of the Donnell-Taylor-von Kármán theory of plastic waves. The results obtained for the propagation velocity and wave-shape changes indicate that the theory fails to describe the dynamic process by its neglect of strain-rate and creep effects.

From authors' summary by M. C. Steele, USA

1029. **Grasshoff, H., Investigations of values of the dynamic penetration resistance to model piles in sand and clay, obtained from tests,** Proc. Third Inter. Conf. Soil Mech. Foundation Engng., Aug. 16–27, 1953, vol. II, 47–50.

Author's summarization, quoted here, is quite accurate.

"Writer presents the results of tests in which rapidly moving model piles were photographed by high-frequency, slow-motion camera as they penetrated into sand. The curve of dynamic resistance was obtained from double graphical differentiation of

the space-time diagrams obtained in the tests. The physical factors that influence the dynamic resistance are deduced on the basis of the conformity of the resistance diagrams to mathematical laws. The results are compared with those of similar tests carried out in clay and with the results of pile-driving tests in sand. The investigations are of interest in connection with the theory of dynamic pile-driving formulas and their practical applications." W. L. Orr, Pakistan

1030. Ursell, F., Short surface waves due to an oscillating immersed body, *Proc. roy. Soc. Lond.* (*A*) **220,** 1140, 90–103, Oct. 22, 1953.

A very long circular cylinder of radius a, with its axis horizontal, is half immersed in an incompressible and inviscid fluid under gravity. The cylinder is given a vertical forced simple harmonic motion of small amplitude about its initial position. A surface disturbance is set up in which waves travel away from the cylinder and a stationary state of motion is rapidly attained. In a previous paper, the author found that, for the stationary case, the resultant two-dimensional fluid motion depends on a single dimensionless parameter $N = \sigma^2 a/g$, where $2\pi/\sigma$ is the period and g the gravitational acceleration. The solution was expressed in form of a series of expansion. While the two derived series for the velocity components converge in principle for all N, the calculation was easy only for small N. The author therefore takes up again the same linearized problem. The solution is now made to depend on an integral equation which can be so chosen that its kernel is small, tending to 0 as N tends to infinity. The equation is solvable by iteration for large N, the solution being not only convergent in principle, but successive terms are found to be in strictly decreasing order of magnitude. The two largest terms are obtained. Expressions are also given for the virtual-mass coefficient and for the wave amplitude at infinity. The author expresses reasonable hope that the technique employed in the paper may be extended to general three-dimensional problems and to the diffraction problems of acoustics and optics, leading to a proper understanding of Huyghens' principle and its extensions. J. K. Lunde, Norway

1031. Keulegan, G. H., Characteristics of internal solitary waves, *J. Res. nat. Bur. Stands.* **51,** 3, 133–140, Sept. 1953.

The laws of wave motion on the interface between two fluid layers of different density are studied by applying method of approximations of Boussinesq. It is assumed that the layers are of constant total depth and initially at rest. The complete differential equations and boundary conditions are outlined and most of the paper consists of two particular cases detailed. First approximate solution gives characteristics of waves of infinitesimal height. Two distinct celerities are deduced; one is for ordinary surface waves with a correction for the two-fluid system, and the other is for interfacial waves. One unusual result is that the velocities are opposite in the two layers and that a hump on the interface is accompanied by a depression in the free surface. Second approximate solution yields properties of the internal solitary wave; an expression for the celerity is derived. Equation for the shape is given for the velocity of propagation very small.

No experimental results verifying the equations are included, although the author indicates that they are at hand and will be published in the future. Reviewer finds the paper clear, concise, and easy to follow. He believes that it will provide a good starting point for any engineer working with density currents and two-fluid systems. W. D. Baines, Canada

1032. Becker, E., Waves from a moving point disturbance in a dispersive medium (water) (in German), *ZAMM* **33,** 8/9, 305–306, Aug./Sept. 1953.

A pressure point moving over a water surface with constant velocity sets up a system of ship waves. The phase velocity is assumed to be a known function of the wave length, though not necessarily the usual one. The author asks under what conditions the wave system is confined to an angle behind the pressure point. His argument is unfortunately so brief as to be obscure, and the reviewer feels doubtful about the validity of some of the conclusions. No reference is made to Lamb's "Hydrodynamics," 6th ed., 1932, §256b, or to the important paper by A. S. Peters [AMR **3,** Rev. 1726]. In that paper it was shown that the lines of constant phase are not exactly similar curves, as the author's argument seems to imply.

F. Ursell, England

Elasticity Theory

(See also Revs. 995, 1026, 1046, 1052, 1056, 1057, 1058, 1065, 1067, 1136)

1033. Westergaard, H. M., Theory of elasticity and plasticity, Cambridge, Mass., Harvard Univ. Press, 1952, xii + 176 pp. $5.

It is indeed unfortunate that Professor Westergaard's terminal illness prevented him from finishing this delightful book. For here we have the first half of a treatise which is most refreshing to read. The book is written for the first-year graduate student in a manner which he will find easy to study. The content is elegant and of a fundamental nature. The mathematics is simple enough so that any graduate engineer should comprehend the formulation of physical problems without difficulty.

The text starts out with a chapter entitled "Scope," where the basic definitions and discussions of elasticity, plasticity, homogeneity, isotropy, and the relation between theory and experiment are discussed. Once the author has established a rapport between the subject matter to be treated and the student he goes on to the next chapter called "Historical notes." One has the feeling that the novice is being led by the hand and shown the history of elasticity unfold before his eyes. The history consists of the great advances in the field from Galileo, Hooke, Bernoulli, and Euler to the 1940's. It must be remembered that it is presented to the student who as yet has not been introduced to what to him are no doubt the mysteries of the theory of elasticity and plasticity, and consequently, the context is on a generally simple level. The first-year graduate student should be able to understand the significance of this chapter, although the finer points can only become apparent to him after a thorough understanding of the theory.

Next, the fundamentals of stress are taken up. First the usual simple notions of the stress components, plane stress, and Mohr's circle are given. At this point, the tone changes and the more complex introductory material is given, such as vectors, three-dimensional state of stress, the stress tensor, octahedral stress, stress deviations, and the equations of equilibrium.

The title of the fourth chapter, "Strain, Hooke's law, the basic equations, elasticity and the simplest possible laws of plasticity," describes its content. The vector and tensor treatment initiated in the previous chapter is continued. The reviewer feels that it is unfortunate that no mention is made of the large deflection theory. The student is apt to get the impression that the strains are at all times only functions of the first derivatives of the displacements. The treatment on plasticity here is exceedingly brief (4 pages) and, the reviewer feels, is incomplete in view of the title

of the book. The discussion centers on possible laws of yielding and fracture and no attempt is made to even formulate a problem in the theory of plasticity. No doubt, had the author been allowed the time, he would have presented a considerably more complete outline of plasticity.

The fifth chapter deals with the application of fundamentals to the solution of classical elastic problems. Its title is "Strain potential and applications to hollow cylinders and spheres, vertical forces, and thermal stresses." The chapter is essentially brief but it does give a good introduction to the formulation and method of solution of some of the more common elasticity problems.

The next and final chapter is by far the most elaborate and one has the feeling that this is where the most important part of the book starts and would have continued from here. The following are some of the more important problems presented: Galerkin vector, twinned gradient; the problems of Kelvin, Boussinesq, Cerrutti, Mindlin, and Hertz, stress concentrations, and the rotating thick-disk problem. The treatment of the Galerkin vector and its applications are perhaps the most complete to be found in an English text.

In conclusion, it is worthy to note that the book is most suitable for first-year engineering students of the theory of elasticity. The presentation is fresh and stimulating and sufficiently different from that found in Timoshenko's book to warrant its publication. It has a number of problems and many references. It does not, however, cover the theory of plasticity to any extent. There are further omissions in its lack of treatment of the important bending and torsion problems, of variational principles, of plates and shells, and of instability considerations. It is obvious that these were not intentionally omitted by the author but forced upon the book by unfortunate circumstances.

H. H. Hilton, USA

1034. **Das, S. C., Stress concentrations around a small spherical or spheroidal inclusion on the axis of a circular cylinder in torsion,** ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-2, 5 pp.

Stresses are calculated for the case of a small elastic inclusion bonded (i.e., continuous displacements and tractions across the surface of the inclusion) to a large circular cylindrical shaft. The inclusions considered are of spherical and spheroidal shapes. The results are discussed for several particular cases.

From author's summary

1035. **Hughes, D. S., and Kelly, J. L., Second-order elastic deformation of solids,** *Phys. Rev.* (2) **92,** 5, 1145–1149, Dec. 1953.

Expressions for velocities of elastic waves in prestressed solids are derived using Murnaghan's theory of finite deformations and third-order terms in the energy. For isotropic materials, in addition to Lamé constants λ and μ, three additional constants, l, m, and n, are required to describe the material. By measuring transmission time of elastic pulses through material, the velocities of longitudinal and shear waves are determined as a function of applied stress. By subjecting material to hydrostatic pressure as well as simple compression, it is found that seven functions of l, m, and n can be measured and thus numerical values calculated. Results are given for polystyrene, iron, and Pyrex glass.

G. W. Housner, USA

1036. **Karush, W., and Martin, A. V., Thermal contraction of a split hollow cylinder,** *J. appl. Phys.* **24,** 12, 1427–1431, Dec. 1953.

Solution is given for closure of split hollow cylinder having radial flow of heat. The heat is considered to be either generated in the tube material or supplied at the tube surfaces. The limiting condition is given for which the free tube will neither close nor open. This gives the temperature condition beyond which the tube will not hold snugly to an enclosed nonexpanding rigid interior. Numerical results are presented for tubes that are insulated externally and cooled internally with heat generated in the tube material; insulated externally and cooled internally through an insulator with heat generated in the tube material; heated externally and cooled internally; and cooled internally and externally with heat generated in the tube material. An equation is presented giving the pressure of the tube against the nonexpanding rigid interior.

S. Levy, USA

1037. **Lessen, M., On similarity of thermal stresses in elastic bodies,** *J. aero. Sci.* **20,** 10, 716–717, Oct. 1953.

The purpose of the discussion is to determine what criteria are necessary for similitude of thermal stresses for geometrically similar model and prototype. By a consideration of the pertinent dimensionless equations, it is demonstrated that, if the model and prototype are exposed to the same thermal conditions, the thermal stresses will be the same. The time scale, however, of the stress history will vary as the square of the linear dimension scale.

A. D. Schwope, USA

1038. **Sestini, G., Thermomechanical computation of pipes with compensation pitches** (in Italian), *Termotecnica* **9,** 9, 399–406, Sept. 1953.

Author derives formulas for axial and radial thrusts in such pipes. Failure is due to fatigue and not to maximum stress. Paper has a dearth of definition of symbols and a surfeit of algebra.

D. R. Bland, USA

1039. **Cross, Howard C., High temperature test data and their importance in design,** *Prod. Engng.* **24,** 10, 182–187, Oct. 1953.

A general discussion of problems currently met with in designing high-temperature alloy components for service temperatures up to 1800 F. Data on high-temperature stress rupture and stress deformation are presented graphically for titanium, stainless alloys, cobalt alloys, etc. Cyclic stress and cyclic temperature properties are discussed. (Most of these results are ostensibly drawn from earlier work; see AMR **6,** Rev. 491.) Stress-rupture behavior of molybdenum and molybdenum-base alloys, in vacuum, is discussed for temperatures up to 2000 F. Results indicate the superior high-temperature performance of molybdenum. However, the problem of protecting molybdenum from oxidative corrosion has not been solved. No bibliography is included.

J. T. Bergen, USA

1040. **Melan, E., Thermal stresses in plates with heat transfer across the surfaces** (in German), *Öst. Bauzeitschr.* **8,** 5, 89–92, May 1953.

Author considers the case where the temperature of the plate T and of the surrounding medium Θ are functions of x, y; moreover, $\nabla^2\Theta = 0$. In such a case, the temperature difference is governed by the equation $(\nabla^2 - 2k/\lambda\delta)(T - \Theta) = 0$ where k is heat-transfer coefficient, λ conductivity, δ plate thickness. The diplacement potential, which furnishes the displacements $(u, v) = \text{grad } \Phi$ and from which the stresses are obtained by further differentiation, is shown to be $\Phi = (\lambda\delta/2k)(1 + \mu)\alpha T$, where α is coefficient of linear expansion, μ Poisson's ratio. Theory is applied to an infinite plate with a hole, heated along the edge of the hole.

G. Horvay, USA

1041. Yoshimura, Y., On the definition of stress in the finite deformation theory, *J. Phys. Soc. Japan* **8,** 5, 669–673, Sept.-Oct. 1953.

Stresses are defined and the equilibrium equations corresponding to the definitions are formally presented in terms of tensors, as well as curvilinear coordinates. Y. V. G. Acharya, Holland

1042. Reissner, E., On a variational theorem for finite elastic deformations, *J. Math. Phys.* **32,** 2–3, 129–135, July-Oct. 1953.

The Euler equations of the variational problem of the theory of finite elastic deformations of a body consist of differential equations of equilibrium and the stress displacement relations in the interior of the body, for which the stress and the displacement boundary conditions are natural boundary conditions. Application is made to the problem of finite bending of plates. The method appears to be comparatively more general than that given by Kirchhoff, Marguerre, and Wang.

M. M. Stanišić, USA

1043. Gasparini, I. C., On the deformation of an elastic, homogeneous, anisotropic solid with a linear stress distribution (in Italian), *Ann. Scu. norm. sup. Pisa* (III), **7,** I-II, 1–15, Jan.-June 1953.

Author first obtains a general expression for the displacements using a formula due to Volterra. A study is then made for the particular cases of (1) simple tension of a cylinder of general cross section, first including body forces (heavy cylinder), then neglecting them; (2) torsion of an elliptic cylinder; and (3) uniform flexure of a cylinder of arbitrary cross section. It is shown that the 21 elastic constants can easily be obtained by testing light rectangular parallelepipeds in simple tension and circular cylinders in torsion. Vector notation is used throughout.

F. DiMaggio, USA

1044. Ōkubo, H., Approximate approach for the torsion problem of a shaft with a circumferential notch, *Rep. Inst. high Speed Mech., Tōhoku Univ.* **3,** 1–9, Mar. 1953.

An approximate solution is obtained for the stress concentration at circumferential notches in a circular shaft. They are obtained by considering the torsional equilibrium of the thin shell contained between the surface of the shaft and an adjacent stress line. The variation of the thickness of this sheet along the shaft is obtained by approximating the shear stress line by the corresponding streamline in fluid flow along a wall and over an obstacle the same shape as the notch. The well-known solution for the two-dimensional flow around the semicircle and semiellipse in the half plane are used to obtain stress-concentration factors for the corresponding notches. The factors are shown to be in very good agreement with known exact solutions.

J. E. Duberg, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1020, 1024, 1026, 1036, 1044, 1081, 1099, 1155, 1228)

1045. Benscoter, S. U., A theory of torsion bending for multicell beams, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-27, 10 pp.

Author presents an approximate torsion-bending theory for multicell beams with sufficient accuracy for engineering design, taking into account arbitrary loading and boundary conditions and cross-sectional shape. Theory rests on the fundamental assumption that basic transverse distribution of axial displacements due to warping torsion is equal to distribution at the same cross section of a uniform beam computed by Saint Venant theory. Method of von Kármán-Christensen is corrected by an appropriate modification of spanwise variation of stresses and rotations. Each approximation introduced has its analogy in engineering bending theory.

Conditions of equilibrium and continuity lead to two differential equations for the two unknown strains (warping displacement w and rate of twists θ). Assumption of basic transverse distribution of strains makes possible the computation of its spanwise variation. Introducing the rotation Φ, author obtains from these two equations the basic differential equation of torsion bending which is exactly analogous to bending with axial tension, when effect of shearing strains is considered. Finally, calculation of normal stresses by warping moments as well as Saint Venant and secondary shear flows by conditions of continuity and equilibrium, is presented. We learn from a numerical example of a regular three-square cell beam how to calculate basic distribution on a cross section. This theory may be applied to calculating multicell wings for airplanes as well as hollow box girders for structural engineering, and theory can also be extended for idealized stiffened sections. H. Beer, Austria

1046. Taylor, J., Stresses in built-up beams due to an abrupt change in shear stress at a loading station, *Aero. Res. Counc. Lond. Rep. Mem.* 2775, 18 pp., Aug. 1949, published 1953.

Owing to the abrupt change in shear stress at loading sections of beams there is a concentration of direct stress in the outer fibers of the beam near the loading section. A method of calculating this concentration is described. The highest stress concentrations occur in short deep beams and are greater for wooden than for metal beams. The method is applied to the spars of two wooden aircraft, and stress concentrations 1.06 and 1.4 are found at the fuselage attachments. Strain measurements were made at positions on a wooden beam under load and the theoretical predictions verified.

From author's summary by G. V. R. Rao, USA

1047. Horvay, G., Gray, R. T., and Born, J. S., Solution of beam problems by biharmonic polynomials which separate the effects of boundary shears and boundary normal stresses, *Gen. Elec. Rep. KAPL-953,* 95 pp., June 1953.

Biharmonic polynomials are given which separate the effect of boundary shear stresses and boundary normal stresses. As a result, a convenient method is provided for solution of certain beam problems in which Fourier expansions (frequently of unsatisfactory convergence) were formerly used. The method is compared with the still simpler but approximate method of self-equilibrating polynomials, and it is found that the latter is adequate for most engineering problems.

From authors' summary

1048. Russell, W. T., and MacNeal, R. H., An improved electrical analogy for the analysis of beams in bending, *J. appl. Mech.* **20,** 3, 349–354, Sept. 1953.

A practical electrical beam analogy which employs ideal transformers is derived from the equations of a segment of nonuniform beam which is loaded by vertical shears and moments applied at its ends. This analogy is suitable for the solution of static-load problems, vibration problems, and transient-load problems. The superiority of this analogy over an analogy derived by replacing differential operators by difference operators is demonstrated by means of error calculations for uniform cantilever and simply supported beams.

From authors' summary by M. Pei, USA

1049. **Culver, R., A simple electrical network analogue for the solution of the rectangular beam stability equation,** *Austral. J. appl. Sci.* **4**, 3, 371–379, Sept. 1953.

Paper outlines the use of a simple electrical resistance network in solving the beam-stability equation for rectangular sections. The present apparatus is in its most elementary form; for convenience in use it could be readily modified to iterate automatically. The possibility of extending this technique to sections in which warping is of consequence is being examined. Simple extrapolation techniques are applied to enhance accuracy attained from quite large meshes (that is, small mesh numbers).

From author's summary

1050. **Brock, J. E., Flexibility of piping systems supported by equally spaced rigid hangers,** ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-6, 8 pp.

Exact methods are developed for the analysis of single-plane piping configurations in which there occur long horizontal runs supported on equally spaced hangers of rigid type. Two important cases are treated in detail and are illustrated by examples.

From author's summary

1051. **Fichera, G., Torsion of elastic hollow prism** (in Italian), *R. C. Mat. Appl.* (5) **12**, 1/2,163–176, Jan.-June 1953.

Paper examines stress distribution in region around a re-entrant angle on boundary of hollow, prismatic, linearly elastic bar subjected to torsion. Method is based on warping function which is shown to have a stress-singularity producing term at a re-entrant corner $\phi = Cr^a \cos a\theta$ where π/a is the re-entrant angle. Essence of paper is determination of numerical coefficient C for shaft of arbitrary cross section. Paper is devoted to mathematical exposition but states that there are in course of publication some specific examples involving numerical processes of successive approximations for determining value of C. Author states chief value of method is for comparing stresses at two or more re-entrant angles on same shaft to determine at which there is greatest danger of failure. He does not mention the effect of properties of materials, yielding, etc., when there are stress singularities.

G. W. Housner, USA

1052. **Nakazawa, H., Torsion of a shaft with a number of longitudinal semi-circular notches,** *Mem. Fac. Technol., Tokyo Metrop. Univ.* **28**, 3, 116–126, 1953.

Author first expresses basic equations for torsion of a shaft of uniform cross section in terms of general orthogonal curvilinear coordinates. Then by use of the mapping function $z = l[\tan(\omega/2)]^{1/m}$, wherein $2m = 2, 3, 4, \ldots$, he obtains specific expressions, as infinite series, for the stress function, shearing stresses, and torque in a shaft with cross section approximating a circle notched by $2m$ peripheral semicircular notches. Numerical calculation of notch-bottom stress and torque for the specific case of four notches ($m = 2$) enables plot of these quantities vs. [*notch-bottom stress/(shaft radius-notch radius)*] and formulation of an approximate equation for notch-bottom stress. The two values for a ratio $\cong 0.6$ prove to be in agreement with corresponding values calculated earlier and otherwise by H. Ōkubo [*Trans. Japan Soc. mech. Engrs.* **18**, no. 65, 1952].

T. J. Higgins, USA

1053. **Krebs, K., and Weidlich, W., Contribution to the theory of the helical spring (estimation of the Poisson ratio of the spring material)** (in German), *Z. angew. Phys.* **5**, 7, 260–267, 1953.

Paper contains generalization of Sommerfeld's theory of helical springs. Considering large deformations and using the theorem of extreme deformation energy, authors derive formulas for coordinates of the spring end. Validity of the theory is then shown by practical example of coupled bending-torsion vibrations of a loaded helical spring, and Poisson's ratio of the steel the spring is made of is estimated by means of the beat-frequency, in which both torsional and bending vibrations are changing. Theoretical results are in good agreement with tests and also explain earlier failures when Sommerfeld's theory of small deformations was used.

V. Kopřiva, Czechoslovakia

1054. **Potthoff, G., The brake effect of a beam-rail brake** (in German), *Eisenbahntechnik* **1**, 4, 164–170, Aug. 1953.

In shunting yards, stationary brakes are used. They are mounted beside the rails and bear horizontal beams which are pressed against the flanks of the wheels of the passing car. The relation between weight, friction force, and braking force is established by means of the moments about the instantaneous rolling center. The ratio of distances of the friction force and of the braking force is introduced as a "rolling-factor." One distinguishes a low, middle, and high position of brakes; the latter is most efficient. Security conditions are considered for derailment as caused by the fore wheels or by the back wheels rising between the beams if pressed too strongly. In this connection, the nod oscillation initiated by braking is discussed.

P.-P. Heusinger, Germany

1055. **Thum, A., and Richard, K., Strength and wear of high-strength transmission gears** (in German), *Schweiz. Arch.* **19**, 9, 267–278, Sept. 1953.

This summary survey of present technology on straight spur gear-tooth strength and wear is a sequel to earlier paper by authors on gear-tooth loading [AMR **6**, Rev. 1516]. The following factors influencing strength are considered: Material, fiber direction and method of forging, fillet geometry, heat-treatment for case-hardened and other steels, surface finish; also, short references are included to the effects of size and shape factors, operating temperature, rim size (for ring gears), and load history. Paper discusses abrasion, wear (pitting), and spalling. Design of optimum gear tooth and methods of raising strength by modifications in tooth geometry are treated in conclusion. Paper is well illustrated and contains considerable numerical information and bibliography.

G. A. Nothmann, USA

Plates, Disks, Shells, Membranes

(See also Revs. 1006, 1023, 1034, 1040, 1072, 1301)

1056. **Kromm, A., Generalized elasticity theory of plates** (in German), *Ing.-Arch.* **21**, 4, 266–286, 1953.

Usually the state of stress at the cylindrical boundary of a bent plate is characterized by three quantities defined per unit of length of the boundary: a bending moment M, a twisting moment W, and a shearing force Q. It is well known that in technical plate theory no "exact" solution ("exact" taken within the scope of the accepted approximations) can be obtained for such problems where M, W, and Q are simultaneously prescribed and that, in such cases, two of the three boundary conditions have to be replaced by one substitute. The reason for this fact has to be sought, of course, in the simplifying assumptions underlying the technical theory. By ameliorating those assumptions, E. Reissner [*J. Math. Phys.* **23**, p. 184, 1944; *J. appl. Mech.* **12**, p. A-68, 1945; *Quart. appl. Math.* **5**, p. 55, 1947] made it possible to fulfill all three boundary conditions. The present author indicates another way to ameliorate the assumptions; generalized differen-

tial equations are deduced, which show analogy with those of Reissner. The results of the latter and the present author are compared in detail. C. B. Biezeno, Holland

1057. Horvay, G., and Clausen, I. M., Stresses and deformations of flanged shells, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-43, 8 pp.

Author presents simplified formulas for the determinations of stresses and deflections in a flanged shell of symmetrical shape with symmetrical loading. He develops his formulas in the customary manner of correcting the stresses and deflections derived from momentless or membrane theory to account for bending stresses near a knuckle or joint. Some consideration is given to thermal stresses and a numerical example is presented in detail.
W. H. Hoppmann, II, USA

1058. Huth, J. H., Thermal stresses in conical shells, *J. aero. Sci.* **20,** 9, 613–616, Sept. 1953.

Equations are presented for thermal and pressure stresses in a cone. These are applied to a sharp-pointed cone from which thermal stresses were computed. A tip bending stress of 140,000 psi was found, which presumably is caused by the radial δt of 1000 F. ($E = 30 \times 10^6$ psi, but thermal expansion is unspecified.) Longitudinal gradients are gentle and appear to have little effect. The author concludes that large temperature gradients must be eliminated to avoid high stresses. H. Becker, USA

1059. Wittrick, W. H., Torsion of a multi-webbed rectangular tube, *Aircr. Engng.* **25,** 298, p. 372, Dec. 1953.

An exact solution is obtained of the elementary recurrence equations for the torsion of a multicelled rectangular cylinder having equispaced identical webs. This is the same problem for which Mansfield [AMR **6,** Rev. 2733] obtained an approximate solution by replacing the internal webs by an equivalent uniform web. M. V. Barton, USA

1060. Deffet, L., and Gelbras, J., The behavior of thick-walled tubes subjected to high pressures (in French), *Rev. univ. Min.* (9) **9,** 96, 725–740, Oct. 1953.

The principal problems involved in the behavior of thick-walled tubes subjected to internal pressure are examined. The classical solutions of the distribution of tension in the elastic and elastico-plastic states are explained, as well as the calculation of macroscopic residual tension in the wall which is produced when the elastic limit is exceeded (autofrettage).

The solution in the elastico-plastic state is compared with experimental curves of distension and its limit of validity is established. Two methods of measuring the distension are described: (1) Measurement of the total increase in volume by the displacement of a determined volume of fluid; and (2) measurement of the increase of the diameter by electrical resistance strain gages. Results are obtained which determine the elastic limit, the limit of total plastic flow, and the fracture resistance for two kinds of steel and differences in tube diameters (internal and external).

With regard to the elastic limit and the limit of total plastic flow, the maximum shear stress criterion agrees satisfactorily with the experiment. With regard to the fracture resistance, no specific criterion is found valuable to use for tubes of relatively large wall thickness. Empirical criteria are generally suitable for thin-walled tubes.

Only fractures of ductile appearance were obtained for the two kinds of steel used in the experiments.
From authors' summary by J. Miklowitz, USA

1061. Peattie, K. R., and Day, G. F., The bending of simply-supported rectangular plates, *Engineering* **176,** 4571, 4573; 308–310, 358–360, Sept. 1953.

Article presents comparison of experimental stress and deflection data with relaxation and series solution of plate-bending equation for centrally point-loaded rectangular plate of 1.5 aspect ratio. Agreement is generally good.
M. L. Williams, USA

1062. Reckling, K. A., The thin circular plate as stability problem with pulsating edge load applied in the middle plane (in German), *Ing.-Arch.* **21,** 2, 141–147, 1953.

Dynamic stability of a thin circular plate loaded uniformly around its edge with a periodic radial compressive force consisting of a constant part P_0 plus a periodic part $P_1 \cos \omega t$. By formulating the problem in terms of its differential equation, the general frequency equation is obtained. From this, the boundary curves between the stable and unstable regions are derived. As an example, the author has plotted these curves for the case of a plate in which the middle curvature vanishes at the edges. In this case, for zero P_0, the boundary curve corresponds exactly with that of a simply supported column under periodically varying forces. Regions of instability also occur when the constant part P_0 of the edge load is tensile. H. Lurie, USA

1063. Yu, Y.-Y., Bending of isotropic thin plates by concentrated edge couples and forces, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-32, 11 pp.

Muskhelishvili's method in which a biharmonic solution is represented in terms of two analytic functions of the complex variable z is used to solve the problem of plates singularly loaded along the edges. The circular plate subjected to isolated bending and twisting couples and concentrated loads is discussed in detail. Numerical results have been obtained for the value 0.3 of Poisson's ratio. It is pointed out that the results of a circular plate bent by two twisting couples may be used in the design of circular gates operated diametrically.
B. R. Seth, India

1064. Fackert, W., Yield point in bending; additional information for thin plates (in German), *Arch. Eisenhüttenw.* 24, 9/10, 407–410, Sept./Oct. 1953.

1065. Paria, G., Stresses in a thin elastic plate with a parabolic boundary due to normal pressures distributed near the vertex, *Bull. Calcutta math. Soc.* **44,** 4, 181–183, Dec. 1952.

Author applies on title problem the special method of Sen [*Phil. Mag.* (7) **39,** p. 992, 1948] for two-dimensional boundary-force problems. M. Botman, Holland

1066. Maud, F. E., and Thorne, C. J., Thin plates under combined loads I, *Studies appl. Math. Univ. of Utah* no. 7, 46 pp., Apr. 1952.

Paper contains solution of problem of small deflections of uniform elastic isotropic rectangular plate with distributed lateral load $q(x, y)$ and constant membrane forces (N_x, N_y), with rather general boundary conditions. Following types of boundary conditions are considered: Type 1, deflection and slope given. Type 2, deflection and bending moment given. Type 3, bending moment and shear given. Two parallel edges are required to have boundary conditions of type 2. Each of the other edges may have any of the three preceding types of boundary conditions.

The differential equation of the problem

$$D\nabla^4 w = q(x, y) + (N_x w_{xx} + N_y w_{yy})$$

is solved by method of sine transform. Solutions are expressed by single trigonometric series. Sine transforms of several special load functions $q(x, y)$ are listed. H. L. Langhaar, USA

1067. Salvadori, M. G., Stresses and displacements in thin shells composed of cylindrical and spherical segments, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 293, 22 pp., Oct. 1953.

This paper concerns the type of analysis required in design of roofs composed of thin shells of reinforced concrete. The actual analysis deals only with the problem of a "barrel" roof (half of a cylindrical shell in horizontal position closed at the ends by shells which form quarter spheres) supporting a uniform vertical load. The author first obtains membrane stresses for cylindrical and spherical parts separately, as if they were cut apart. Appropriate solutions which take account of bending near the boundary between spherical and cylindrical parts of the composite shell are next superimposed in order to make all stresses and displacements continuous across the boundary. This is accomplished by making various approximations or simplifying assumptions and by use of certain published tables ["Design of cylindrical concrete shell roofs," ASCE Manual of engineering practice no. 31, 1952]. The problem reduces, mathematically, to solving a set of three simultaneous algebraic equations, which are analogous to equations arising in the analysis of any statically indeterminate structure. An explicit solution of these equations is not practical in the general case, so that the author does not obtain complete results in explicit form. No numerical examples are discussed, but some indication as to how the same type of analysis might be applied to slightly different problems is given.

R. A. Clark, USA

1068. Zhgenti, V. S., Application of functional analysis to the theory of slanting thin-walled elastic shells (in Russian), *Dokladi Akad. Nauk. SSSR (N.S.)* **91,** 2, 217–219, July 1953.

A shell as described in the title is subjected to an arbitrary continuously distributed load with the boundary conditions that the displacements and the normal strains vanish at the boundary. Author proves only the existence of a solution. He first obtains the partial-differential equations of equilibrium in conventional form and then transforms the problem into real Hilbert space, using symbolic operators. He shows by means of functional analysis that the sequences of displacements and strains are convergent; hence the problem has a solution.

Functional analysis is a branch of mathematics which is concerned with properties of functions whose arguments need not be real or complex numbers, but are abstract elements, which may be, for example, matrixes or operators. In functional analysis we often meet abstract spaces, like Banach or Hilbert spaces. It is implicit in the author's work that a slanting shell is defined as an open shell of small curvatures. T. Leser, USA

Buckling Problems

(See also Revs. 1062, 1079, 1080, 1099)

1069. Bijlaard, P. P., Fisher, G. P., and Winter, G., Strength of columns elastically restrained and eccentrically loaded, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 292, 52 pp., Oct. 1953.

Paper develops approximate theoretical methods for the calculation of the maximum loads carried by struts eccentrically loaded and elastically restrained, due allowance being made for the effects of plasticity. Comparison with reported experimental results shows good agreement. Work forms part of a general investigation into the buckling of members in a stiff-jointed framework.

W. S. Hemp, England

1070. Bijlaard, P. P., and Fisher, G. P., Column strength of H-sections and square tubes in postbuckling range of component plates, *NACA TN* 2994, 106 pp., Aug. 1953.

The column buckling stress in the range where the component plates have buckled is calculated by the method of split rigidities. For the elastic range, simple formulas are derived which explicitly express the column buckling stress in terms of the Euler buckling stress of the column, the plate or local buckling stress, and the local buckling stress for a higher mode of buckling. For the plastic range, a Johnson parabola is proposed which, in the buckling-stress-slenderness diagram, is tangent to the curve for the elastic column buckling stress in the postbuckling range. Also the case of initially crooked columns is considered.

Tests were carried out for a considerable range of slenderness ratios on three H-sections and two square tube sections. The experimental ultimate buckling stresses are in excellent agreement with those predicted by the theory.

From authors' summary by A. Phillips, USA

1071. Davidson, J. F., Buckling of struts under dynamic loading, *J. Mech. Phys. Solids* **2,** 1, 54–66, Oct. 1953.

The elastic behavior of a hinged, initially curved strut struck axially at one end by a mass via a spring is investigated on the basis of N. J. Hoff's equation of lateral motion of a dynamically loaded column plus an equation for longitudinal motion under this action. It is found that under most practical conditions, effects of stress waves and of lateral bending are not simultaneously important so that, at any time, the load can be considered as constant throughout the length of the column. It is also found that in most practical cases strut shortening does not affect load intensity appreciably. Calculating-machine results indicate that the dynamic load corresponding to a given deflection may be sizably larger than the static load corresponding to the same deflection, provided the load frequency is larger than or at most equal to the strut frequency. It is also shown that if the reverse is true the dynamic load is never significantly smaller than the static load for the same deflection, within the range of investigated parameters. A limited amount of experimental evidence appears to confirm the theory satisfactorily. Results are said to be applicable to the design of cranes, railway carriages, or airframe components. G. Winter, USA

1072. Gerard, G., Bending tests of thin-walled sandwich cylinders, *J. aero. Sci.* **20,** 9, 639–641, Sept. 1953.

Paper reports results of 6 bending tests on sandwich cylinders of 6-in. radius and $^1/_8$-in. wall thickness. Four tests of cylinders with cellular cellulose acetate cores (a material of low shearing stiffness) show maximum stresses about 32% higher than predicted by theory. Previous direct compression tests had shown close agreement with theory. These results are in agreement with known behavior of thin-walled monocoque cylinders.

Theory indicates that maximum stress should be proportional to the shearing modulus of the core. Two tests with end-grain balsa cores (a material having stiffness five times as great as cellular cellulose acetate) showed maximum stresses slightly lower than those of the specimens with cellulose acetate cores. No reason for this large discrepancy between theory and experiment is apparent, although the author suggests that it may be due to poor bonding of the skin to the core.

S. U. Benscoter, USA

Joints and Joining Methods

1073. Broding, W. C., Criteria for designing adhesive bonded joints, *Prod. Engng.* **24,** 10, 144–147, Oct. 1953.

Considerable advancement in the design of lightweight aircraft structures has been made through the use of metal-to-metal bonding. As these structures must have sufficient reserve strength to withstand extreme operating temperatures, joint stresses must be carefully analyzed. The method described simplifies this task. From author's summary

1074. Gray, A. N., Room-temperature compound process, *Mech. Engng., N. Y.* **75,** 8, 625–628, Aug. 1953.

Structures

(See also Revs. 1069, 1071, 1110, 1121)

1075. MacNeal, R. H., Application of the compensation theorem to the modification of redundant structures, *J. aero. Sci.* **20,** 10, 726–727, Oct. 1953.

A method is presented to simplify calculations for statically indeterminate structures in the special case where several structural parameters, but not all, are varied. One standard case is solved in matrix form, the structural parameters forming a square matrix of order n. Changes in structural parameters are assumed to occur in the first m rows and columns of this matrix, where m is less than n. Changes in the unknowns corresponding to the assumed structural parameter changes are shown to depend only upon the first m rows and columns of the inverse of the unmodified structural parameter matrix. Calculations are shown in detail for $m = 1$. H. J. Plass, Jr., USA

1076. Craemer, H., Contribution to the mechanism of plastic strain equalization in structures under bending (in German), *Ing.-Arch.* **21,** 3, 187–190, 1953.

The concepts of redistribution of tensions in a section, moments in a structure and then tensions in a structure are clearly stated and then analyzed, illustrating with graphs the relations of forces and corresponding deformations in the different cases.
A. J. Bignoli, Argentina

1077. Kennedy, A. J., The design of constant stress cantilevers, *J. sci. Instrum.* **30,** 10, 371–374, Oct. 1953.

The stress-strain properties of spring cantilevers under large deflections are examined theoretically in sufficient detail to provide a basis for the design of a constant stress device. The construction and performance of a particular device are described in order to impose a constant tensile stress on a specimen deforming under creep. This device provides for an automatic change in applied load to compensate for the changing cross section under test. The author presents performance results of a working model and claims that the device is suitable for large-scale testing at fairly slow creep rates. J. Aronofsky, USA

1078. Watson, C. G., Forms of sections for struts, *Engineer, Lond.* **196,** 5088, 133–136, July 1953.

Article attempts to evolve the most efficient form of section for use as a strut, consistent with its practical usefulness in the construction of transmission-line towers and similar structures.
From author's summary

1079. Nowacki, W., On the application of finite differences in structural mechanics (in Polish), *Arch. mech. stos.* **3,** 3/4, 483–512, 1951.

Author presents in very uniform and systematic manner the solutions of many problems, typical for structural mechanics, and shows the analogy between the solution of difference equations and the solution of integral equations. The derived solutions are given in general form and are obtained by use of the conjugate matrix of the system of equations containing three or five terms. The theory of difference equations is here applied to solving the following problems: The simultaneous bending and compression of a straight bar, and the transverse vibrations of rectangular plates compressed by forces distributed nonuniformly. In particular, author solves, by the method of finite differences, the case of vibrations of a bar with variable cross section, when the determination of the frequency of vibrations causes several difficulties. Author, analyzing the buckling of the plate, replaces the difference equations of fourth order for the rectangular plate by a system of difference equations of second order. The work contains numerical examples of calculations and compares the results obtained by the method of finite differences with results obtained by other methods. W. Wierzbicki, Poland

1080. Mortelmans, F., Practical calculations for reinforced-concrete columns (in Dutch), *Tech. Wet. Tijdschr.* **23,** 10, 220–223, Oct. 1953.

Instead of the formulas for the buckling coefficient of columns due to Rankine and others, author suggests an empirical formula. Applying this formula to two sections, graphs have been drawn showing the coefficient as a function of the section characteristics with l as a parameter. Numerical examples explain the practical application of these graphs in some specific cases.
Y. V. G. Acharya, Holland

1081. Lee, L. H. N., Inelastic behavior of reinforced concrete members subjected to short-time static loads, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 286, 25 pp., Sept. 1953.

The stress-strain curve to the point of maximum stress is determined on the basis of compression cylinder tests. This is approximated by a parabola, with the portion beyond the maximum stress point also assumed to be parabolic. With this stress-strain relationship, the moment-curvature relation is developed. Author shows that the beam deformations actually observed are consistent with the cylinder stress-strain curve, although the maximum stress falls at a strain about 16% greater than that found with the cylinders.

The results of 216 beam tests (reported by earlier authors) are compared to an ultimate moment equation developed in this paper (standard deviation ± 0.062 on the basis of 1.00 for perfect agreement).

Relationships for eccentrically loaded spiral columns are also developed and checked against Hognestad's column tests.

Author shows that moment-curvature relations theoretically vary greatly with the amount of steel used. Collapse loads on beams are discussed and an over reinforced beam loaded at the third points is analyzed. Failure is assumed to occur when the *end* moment reaches the maximum strength of the beam, at 5.4% larger load capacity than indicated by elastic analysis. This does not agree with the usual method of finding collapse loads, which assumes the formation of a hinge and some further load capacity on the beam. Author does not discuss this possibility or the reasons he ignores it.

Tests on three fixed-end beams with varying steel are reported with strengths from 33 to 35% greater than indicated by the elastic theory. Reviewer notes that beam failures do not show

at points of maximum negative moment but rather in positive moment sections. This indicates either considerably less than full end fixity or some redistribution of moments at high loads. Reviewer suggests the latter as the more reasonable explanation.
P. M. Ferguson, USA

1082. **Jäger, K., On the analysis of reinforced-concrete slab joists** (in German), *Öst. Bauzeitschr.* **8**, 3, 58–64, Mar. 1953.

Paper considers a continuous slab-joist system. The effects of the torsional rigidity of both longitudinal and transverse joists are fully explored for a concrete example. The bending rigidity of the roadway slab is neglected in comparison with that of the transverse joist. Y. C. Fung, USA

1083. **Takabeya, F., Murakami, Y., and Takabeya, R., Stress investigations of rigid frames, considering the effects of bending moments, normal and tangential stresses,** *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **2**, 5, 15–37, Mar. 1953.

Rigid frames of uniform sections are analyzed by virtual work. Moments for frames of one and two stories and of one and two bays are given. These moments are compared with moments obtained from an analysis which includes the distortion due to direct and shearing stresses as well as bending stresses. Moment variations are expressed as errors and related to height-span ratios for different structures. Curves show, for conventional structures, that an analysis neglecting direct and shearing stresses is satisfactory. E. D'Appolonia, USA

1084. **Nowacki, W., and Dabrowski, R., Silos—methods of calculation and construction [Silosy—Metody obliczeń i konstrukcji]**, Warsaw, Państwowe Wydawnictwa Techniczne, 1953, 301 pp.

Book represents an extensive and informative monograph of four parts: I. Calculation of the pressure of loose materials in silos according to the methods of Janssen, Airy, Dörr, and Froelich, with a critical comparison of these methods. II. Statical calculations of rectangular and spherical silo compartments, and the theory of bending of the cylindrical vault with variable and nonvariable thickness. The calculation of the hopper, low edge of compartment walls (plate girders) and foundations. III. Construction of silos by using different methods of execution. IV. Several accurately described examples of executed constructions.

In this book, authors show the latest extent of science and practice in the calculation and construction of silos, based on accessible world literature. The book belongs among the most valuable publications of the Polish construction literature.
J. Nechay, Poland

1085. **Taylor, J., Structure weight,** *J. roy. aero. Soc.* **57**, 514, 646–652, Oct. 1953.

This paper is primarily concerned with the structural weight of jet aircraft as related to their size and shape rather than the saving in the structural weight that may be affected by improved methods of construction. The author compares the effect of wing aspect ratio and wing thickness/chord ratio upon the structure weight, power plant plus fuel weight, and gross weight for a transport airplane having a speed of 600 mph, a range of 4000 miles, at an altitude of 40,000 ft, carrying a fixed useful load of approximately 20% of the gross weight. The structure weight and aerodynamic drag are obtained from empirical formulas which are neither shown nor referenced in this paper and which take into account the following variables: g factor, speed, wing aspect ratio, wing thickness/chord ratio, surface area, fuselage dimensions, and power-plant dimensions. The fuel consumption and thrust are assumed directly proportional to air density and power-plant weight.

The cost of structure, and power plant plus fuel per lb per hr of flight is determined for foregoing airplane for a life of 30,000 hr in 10 years and for a life of 5000 hr in 10 years. The paper is extended to cover the cost of structure per lb per flying hr and of power plant plus fuel per lb per flying hr for a jet-type fighter.

From these studies the author concludes that for all jet aircraft except the long-range bomber the cost per lb per flying hr of the power system is greater than that of the structure and the cheapest aircraft will be one with a greater structural weight than that of the aircraft designed for minimum gross weight. Stated in simpler terms, the author concludes that the most economical jet transport or fighter is not one which has the minimum gross weight but rather one in which structural weight has been added, most likely by employing a thinner wing, so as to obtain an improvement in the aerodynamic drag and consequently a reduction in the power and fuel requirements. K. Arnstein, USA

1086. **MacDonough, E. P., The minimum weight design of wings for flutter conditions,** *J. aero. Sci.* **20**, 8, 573–574, Aug. 1953.

Paper gives formulas for simple box beams, for determining spanwise distribution of box flange area to provide constant spanwise stress level in fundamental bending or torsion vibration of the beam. This distribution permits most economic use of flange material. W. Targoff, USA

1087. **Solvey, J., Structural efficiency in aircraft design,** *J. Instn. Engrs., Austral.* **25**, 6, 105–114, June 1953.

By using the structural index, author gives expression for the weight and shows curves of the weight parameter against the structural index. He summarizes results for solid round strut, thin-walled round strut, simple truss, stiffened round cylinder in pure bending, and aircraft wing. Some details are given for the wing with consideration of torsion, ribs, shear, and bending. Influence of planform and thickness on the structural efficiency of the wing is considered. Finally, the influence of the wing structural efficiency on aircraft speed, range, and rate of climb is demonstrated by curves. B. E. Gatewood, USA

1088. **Zender, G. W., and Brooks, W. A., Jr. An approximate method of calculating the deformations of wings having swept, M or W, Λ, and swept-tip plan forms,** *NACA TN* 2978 28 pp., Oct. 1953.

The approximate method used by the authors is that the distortion of the outboard portion of a swept wing is computed by the elementary beam theory and is added to the distortions contributed by the triangular root section. This method is applied to solid wings of uniform thickness and of various forms. The agreement between experiment and theory is satisfactory.
S. I. Pai, USA

1089. **Howe, D., Analysis of experiments on swept wing structures,** *Coll. Aero. Cranfield Rep.* no. 65, 19 pp., 27 figs., May 1953.

Report summarizes unpublished results of several experimental investigations of stresses and deformations of swept-wing structures. Comparisons are made with theoretical results for four types of structure, namely, one- and two-cell box beams with ribs both normal and oblique to the spars. At sections distant from

the root, experimental results have good agreement with theories of the author [AMR **6**, Rev. 3726] and Hemp [AMR **3**, Rev. 2207] but poor agreement with theories of Wittrick and Thompson [AMR **3**, Revs. 54, 879]. Near the root sections, agreement is less satisfactory for all theories. Reviewer finds the exposition unfortunately vague about experimental procedures, considering the limited availability of student theses from which experimental information was taken. T. F. O'Brien, USA

1090. Badger, D. M., Analysis and design of multipost-stiffened wings, *Aero. Engng. Rev.* **12**, 7, pp. 45–57, July 1953.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1018, 1041, 1060, 1243)

1091. Gross, B., Mathematical structure of the theories of viscoelasticity, Paris, Hermann & Cie., 1953, 75 pp.

To quote the author, this book "aims at a description of the foundation and structure of the mathematical framework that is common to all theories of linear viscoelastic behaviors." In the opinion of the reviewer, the author has achieved his aim.

Linear viscoelastic theory consists essentially of representing the mechanical stress-strain behavior of linear idealized high-polymeric materials either by a number of Voigt models in series or by a number of Maxwell models in parallel. If an infinite number of such models is used, the theory is sometimes said to be independent of the model concept. It has been shown in the past that the behavior of such materials can be uniquely specified once any one of the following functions has been determined: Distribution function of retardation times of strain $F(\tau)d\tau$; distribution function relaxation times of stress $E(\tau)d\tau$; creep function $\psi(\tau)$; relaxation function $(\bar{\psi}\tau)$; complex compliance function $J^*(i\omega)$; complex modulus function $E^*(i\omega)$.

In the various sections of this book the functions listed above are defined and discussed and the relations between them are either stated or deduced. The book contains a table of distribution functions which have been used in the past and also a fairly representative bibliography.

Reviewer regrets that the author has not paid any attention to general stress-strain relations in addition to those for uniaxial stress strain.

This book is clear and concise and should prove to be of great interest to those who are interested in the time-dependent properties of high polymers. Y.-H. Pao, USA

1092. Neuber, H., Fracture surface theory of the plane anisotropic plasticity problem (in German), *ZAMM* **33**, 8/9, 293–299, Aug./Sept. 1953.

Continuing an earlier paper, author shows that if an arbitrary, anisotropic flow law for plane strain plasticity problems is plotted on the orthogonal axes $(\sigma_x + \sigma_y)$, $(\sigma_x - \sigma_y)$, $(2\tau_{xy})$, a surface is described on which the trajectories of principal stresses coincide with the characteristics of the differential equations of equilibrium. He calls attention to the error involved in considering an anisotropic material as if it were isotropic.

G. W. Housner, USA

1093. Lee, E. H., and Tupper, S. J., Analysis of plastic deformation in a steel cylinder striking a rigid target, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-28, 8 pp.

The Taylor-von Kármán theory of uniaxial plastic-wave propagation is applied to calculate the distortion produced when a cylindrical projectile strikes a target end-on. The computations are for a material which deforms plastically under constant true stress in compression and for which, consequently, the theory predicts shock waves during the impact. The motion of the plastic wave front is shown to agree closely with that calculated by Taylor using the simplifying assumption that Young's modulus is infinite. This smooths out the discontinuities in the permanent strain distribution, which otherwise agrees closely at high impact velocities with the plastic-elastic analysis. Good agreement is obtained with experimental firings of nickel-chrome steel cylinders. R. Hill, England

1094. Marin, J., and Sauer, J. A., Plastic stress-strain relations under radial and non-radial combined stress-loading, *J. Franklin Inst.* **256**, 2, 119–128, Aug. 1953.

Combined stress tests on thin-walled tubing, in which one of the principal stresses is increased while the other is held constant, show that the J_2 type of incremental theory is valid for these conditions. (Reviewer's note: For the conditions of the tests, the difference between the predictions of the flow theory and deformation theory is negligible. Consequently, the tests do not distinguish between these two theories.) J. D. Lubahn, USA

1095. Richter, H., Elastic-plastic reflection of a rod (in German), *ZAMM* **33**, 7, 237–244, July 1953.

A bar of finite length is thrust against a fixed wall with sufficiently high velocity; the material shows no hardening but relaxation. The author investigates the elastoplastic phenomenon of reflection and the state of oscillation remaining after the reflection. It is shown how the coefficient of restitution and the time of duration of the reflection depend on the length of the bar and the velocity. From author's summary

1096. Hill, R., A new method for determining the yield criterion and plastic potential of ductile metals, *J. Mech. Phys. Solids* **1**, 4, 271–276, July 1953.

Author proposes theoretically to supersede complex stress tests of thin-walled tubes by using plane sheet under simple tensile stress (S, say) with flat-bottomed groove on main face, at angle θ to direction of pull, in which to study plastic stress-strain relations. He assumes plane, homogeneous stress throughout sheet (unit thickness, say) and also throughout groove (thickness h, say). (If A, B are normal, shear stresses in sheet at edge of groove, then A/h, B/h are normal, shear stresses applied to edge of subsidiary sheet of thickness h.) Using ideal plasticity theory (considering strain velocities), he gives stresses induced in subsidiary sheet by applied edge stresses A/h, B/h which depend on θ. He hypothesizes oblique relative velocity of the two parts of main sheet which, used appropriately, gives "plastic potential." Value of S gives complex stress (primary) yield criterion of metal in subsidiary sheet.

Reviewer believes author has not found way to induce two controlled principal normal stresses by means of one principal normal stress. Thin-walled tubes give powerful experimental technique for applying at least two controllable principal normal complex stresses because actual values are measurable, approximately, to check any proposed theory rather than use a theory to give stresses acting. K. H. Swainger, England

1097. Yang, C. T., and Thomsen, E. G., Plastic flow in a lead extrusion, *Trans. ASME* **74**, 5, 575–579, May 1953.

Presented are the results of an extrusion experiment using lead at room temperature. (Lead was used for its room-temperature recrystallization properties.) The billet was parted on one of its meridional planes and provided with square grid. The grid was

measured for deformation after a steady extrusion of an appreciable length. After measurement, the extrusion was returned to the press for another extrusion of a small increment and remeasured for the corresponding incremental strains.

An analysis of the incremental strains is presented in graphical form showing approximate flow paths. Stress trajectories were also computed on the basis of the strain analysis.

Significant is the fact that no dead zone in the corner between the die face and the walls of the container was found, contrary to the reports of other writers. W. Schroeder, USA

1098. **Wistreich, J. G., Die pressure in plane strain drawing: Comparison of experiment with theory,** *J. Mech. Phys. Solids* **1,** 2, 164–171, Apr. 1953.

Paper describes an experimental (four specimens) comparison of the Sachs (1927) theory of drawing with the more recent work of Hill and Tupper (1948). The lateral pressure along the working length of the die is measured by pulling strips of solder through dies made of optically stress-sensitive material. On the basis of these four tests, author rejects the theory of Sachs, but he finds significant similarities between the experimental measurements and the theory of Hill and Tupper. E. A. Davis, USA

1099. **Kachanov, L. M., The elastoplastic instability of a bar subjected to combined compression and torsion** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **88,** 4, 627–630, Feb. 1953.

Author shows that the problem of buckling in the plastic range of a bar under twist and axial load reduces to the same problem in the elastic range if corresponding reduced moduli of rigidity, depending on loading and shape of the cross section, are introduced. This result is analogous to von Kármán's theory of plastic buckling of a bar under axial load only. Equations permitting evaluation of the reduced moduli are developed. No numerical data or examples are given. Reviewer comments that, in order to find stresses in the plastic region under the critical load, Nadai's solution, founded upon a "total" strain theory, is used, while strain increments during the buckling are determined—without further explanation—by an "incremental" strain theory.
D. Radenković, Yugoslavia

1100. **Hopkin, L. M. T., A note on the mathematical analysis of creep curves,** *J. Inst. Metals* **81,** 443–448, 1952–1953.

Author finds that constant-stress creep curves obtained with high-purity lead and a lead-1% tin alloy (at room temperature, presumably) are well fitted by the Andrade equation $L_t = L_0(1 + \beta t^{1/3}) \exp Kt$, where L_t is length of specimen at any time t, and by a logarithmic equation $L_t = A\ (1 + B \log t) \exp Ct$, at least for times up to 300 hr. For longer times, up to 5000 hr, the Andrade equation is preferred. Reviewer believes good fit is not surprising in view of author's use of three empirical constants in both analytical approximations. In the Andrade equation, e.g., L_0, β, and K are undetermined; L_0 is regarded as "similar to the length of the specimen immediately after loading" rather than being identified with that length, as is conventional. However, author is not consistent in this usage. In discussing errors involved in calculation of the Andrade constants, he employs conventional definition of true strain $\gamma \equiv \log (L_t/L_0) \cong \beta t^{1/3} + Kt$, with only β and K undetermined. Discussion of errors in calculating L_0 is thus precluded. Author attempts to correlate calculated values of β and K with grain size and stress, but concludes that, owing to the errors involved in calculation of the constants, the significance of the suggested correlations must be accepted with reserve. Author also indicates reserved judgment concerning profundity of physical significance often attached to the Andrade constants. Reviewer shares this skepticism and prefers the simpler exponential approximation $\gamma \cong ct^{\alpha}$ for creep strain under constant stress. L. Green, USA

1101. **Kennedy, A. J., Creep and recovery in metals,** *Brit. J. appl. Phys.* **4,** 8, 225–233, Aug. 1953.

A review is made of the experimental evidence available on the nature of the creep and recovery mechanisms in single-crystal and polycrystalline metals. This leads to consideration of the character of creep when periods of recovery, under reduced stress, are interposed, and it is shown that such conditions have an important effect on the behavior of structures and machines, particularly at high stresses and temperatures.
From author's summary

1102. **Gross, B., Rheological distribution functions** (in German), *Kolloid Z.* **131,** 3, 161–168, June 1953.

Author reviews briefly his attempts at extending the classical theory of the elastic aftereffects in solids originating in the works by Maxwell, Boltzmann, and Wiechert and, more recently, by R. Becker under reference to author's own recently published monograph entitled: "Mathematical structure of theories of linear viscoelasticity" [Paris, Hermann & Cie, 1953, no. 1190 of Series "Actualités scientifiques"]. He characterizes his attempts as a phenomenological approach based on linear relations. Although he concedes that the phenomena may not be of linear nature, he pretends that a linear theory may suffice for the treatment of these aftereffects in a first approximation. In regard to relaxation he starts with an equation: $\sigma = (E_0 + \Psi(t))\alpha_0$ . . . . . [1], which is supposed to express the decay of stress σ suddenly applied to produce a strain α_0, E_0 denoting the "static" modulus of elasticity and where author calls the time-dependent function $\Psi(t)$ a "relaxation function." In the Maxwell and related theories, this function is of an exponential nature. According to author, one has tried to achieve a better agreement by constructing it from a sum of several exponential terms, and he subsequently expresses it by a definite integral: $\Psi(t) = \beta \int_0^{\infty} e^{-t/\tau} F(\tau) d\tau$ . . . . . [2] where β is a normalizing factor and $F(\tau)$ "the distribution function of the relaxation times." He quotes various attempts for defining suitable functions $F(\tau)$ representing solid deformations, but more recently the procedure has been reversed in order to define for a given behavior of material, i.e., for a known function $\Psi(t)$, the required function $F(\tau)$ by using the transformation of variable $s = 1/\tau$ solving $\Psi(t) = \int_0^{\infty} N(s) e^{-ts} ds$, ... [3] by $N(s) = \beta F(1/s)/s^2$ . . . . . [4]; [3] representing a Laplace transform. The functions $N(s)$ have been studied by Bromwich, Wagner, Doetsch, and Widder. Author extends this theory to oscillating deformations and to creep extension under an invariable stress. A. Nadai, USA

1103. **Ericksen, J. L., Characteristic surfaces of the equations of motion for non-Newtonian fluids,** *ZAMP* **4,** 4, 260–267, 1953.

The characteristic conditions of the equations of motion for non-Newtonian fluids are derived and the characteristic directions are determinated in the case of plane flow.
E. Siebel, Germany

1104. **Kempner, J., and Pohle, F. V., On the nonexistence of a finite critical time for linear viscoelastic columns,** *J. aero. Sci.* **20,** 8, 572–573, Aug. 1953.

This brief report describes the results of a mathematical analysis proving the nonexistence of a finite critical time for columns of a linear viscoelastic material. The objective of the report is to show that the conclusion that a finite critical time existed was fallacious. A. D. Schwope, USA

1105. Shield, R. T., and Drucker, D. C., The application of limit analysis to punch-indentation problems, *J. appl. Mech.* **20,** 4, 453–460, Dec. 1953.

See AMR **7,** Rev. 96.

1106. Shapiro, G. S., Determination of the potential energy of residual strains (in Russian), *Prikl. Mat. Mekh.* **17,** 1, 114–116, 1953.

The paper is a sequel to "Release of heat in plastic deformation" by N. S. Fastov [AMR **6,** Rev. 1895] and provides equations for estimating residual energy as a function of strain ratio. Torsion for the circular shaft in case of linear strain hardening is discussed, the value of strain being $e_i = \tau r/(3)^{1/2}$. A parameter $\alpha = e_s/e_{im}$ is introduced; the strain attaining maximum at the cylindrical boundary $r = a$, this parameter becomes $\alpha = r_s/a$. The equation for average residual potential energy is given. The ratio of residual energy to the total work of deformation assumes the following form

$$K = V_{0av}/V_{av} = 2\alpha(1 - g/2\alpha^2 + 4\alpha^3 - {}^1/_2\alpha^6)/(24 - 34\alpha + 3\alpha^3 + 8\alpha^4 - \alpha^7)$$

K becomes zero for $\alpha = 1$ and $\alpha = 0$ and attains a maximum value $K = 0.045$ for $\alpha = 0.7$, i.e., for very small plastic deformations. The maximum value of potential energy of residual strains is $V_{0av} = (2/g)\sigma_s^2/E$ for $\alpha = 0$, and does not coincide with the maximum of K. For metals, this value is of the order 1 kg/cm.^{2} P. Bielkowicz, USA

1107. Braun, I., Schoenfeld-Reiner, R., and Traum, E., An investigation into the rheological properties of bitumen II. A contribution to the theory of the constant-load extensometer, *Bull. Res. Counc. Israel,* **2,** 2, 89–98, Sept. 1952.

Paper describes the theoretical behavior of a two-phase material, one phase being a continuous elastic solid and the other a dispersed viscous liquid, when tested in a constant load extensometer. The extension Δl is referred to the extended length l as proposed by Swainger [Swainger, K. H., *Nature* **160,** 399, 1947] and it is shown that this strain, $\Delta l/l$, per unit nominal traction, if plotted against time for different values of the traction, will give a single exponential curve, provided the elasticity is simple Hookean, i.e., the two-phase material can be described as a Kelvin body. Authors suggest that this fact can be used as a criterion of nature of elasticity of such a material. The theory is tested by results of tests on bitumen, and it is shown that though a single curve is obtained it is not exponential and the authors suggest that more than one Kelvin body is present in bitumen, i.e., it has a spectrum of relaxation times. K. W. Hillier, England

Failure, Mechanics of Solid State

(See also Rev. 1125)

1108. Findley, W. N., Effect of range of stress on fatigue of 76S-T61 aluminum alloy under combined stresses which produce yielding, *J. appl. Mech.* **20,** 3, 365–374, Sept. 1953.

Fatigue results are given for bending and torsion applied separately and combined with mean stresses up to yielding values. Various theories of failure are compared and the significance of mean stress, maximum stress, and crack formation is discussed. R. N. Arnold, Scotland

1109. Hall, E. O., The brittle fracture of metals, *J. Mech. Phys. Solids* **1,** 4, 227–233, July 1953.

Author discusses theory of brittle fracture of metals, particular consideration being given to plastically deformed layer which occurs on fracture surfaces. Results of x-ray studies of this layer for single-crystal and polycrystalline specimens are given. Theoretical study shows that in single crystals a large decrease in plastic work factor may be expected as crack velocity increases. A. M. Wahl, USA

1110. Newmark, N. M., An engineering approach to blast resistant design, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 306, 16 pp., Oct. 1953.

Based on simplified blast pressure-time curves, author suggests approximate analyses for blast loadings on open and covered structures. From idealized load-deformation relationships of a structural element or structure, the required resistance under impulsive loading is estimated. Finally, empirical relations are presented for the energy at and time of the maximum deflection.

Paper represents a thought-provoking approach to a difficult and important problem in structural dynamics. G. G. Meyerhof, Canada

1111. Cottrell, A. H., Theory of dislocations, *Progress in Metal Physics* **4,** pp. 205–264, 1953; New York, Interscience Publishers.

This paper is a review of progress in the theory of dislocations during the past five years. There are 160 references which cover the entire field. Topics covered include the growth of crystals (imperfect) from solutions and vapors, the static creation of dislocations, and dynamic properties of dislocations. A review is given of the characteristic dislocations of all the basic forms of crystals. Attention is paid to interactions of dislocations, the effect of crystal boundaries, slip bands, and obstructions at grain boundaries. Mechanical hysteresis, yield-point theory, strain aging, annealing, creep, and a large amount of material on work hardening is included. While there is nothing particularly new about the material, this paper is an excellent collection of the latest information, well written, clearly set forth, and concisely presented. T. A. Hunter, USA

Material Test Techniques

(See also Revs. 1126, 1136, 1243)

1112. Heyer, R. H., and Lysaght, V. E., Survey of investigations of effect of specimen thickness on Rockwell tests, *ASTM Bull.* no. 193, 32–[illegible], Oct. 1953.

Authors discuss available data from literature and their own test data on this subject. Limiting thickness (LT) below which readings are not intrinsically correct depends on properties of specimen (decreases with increasing hardness level, higher state of cold-working, smoother (lower) surface), applied load (decreases with decreasing load), quality of anvil. Below LT, hardness increases for ball tests (particularly for high loads and low hardness levels) and decreases slightly for Brale tests. Authors applied Rockwell B, F, and 30T tests to steels of different hardness level and thickness obtained by rolling and heat-treating procedures. One number above average hardness of thicker specimens was taken as criterion for LT. LT lines in a P (penetration)-T (thickness) diagram correspond to approximate T/P ratio for the B, F, and 30T scale of 7.9 and 11, hence do neither fully satisfy the criterion of constant T/P nor the criterion of $T/D = 1$ (D is diam of impression) corresponding to T/P ratio ranging from 5 to 13. The method of determining LT based on deviation of linearity of P/*load* at higher load, studied by ASTM committees, is discussed and regarded as unsuitable. J. H. Palm, Holland

1113. **Sutton, R. S., and Heyer, R. H., Correlation of published data for correction of Rockwell diamond penetrator hardness tests on cylindrical specimens,** *ASTM Bull.* no. 193, 40–41, Oct. 1953.

Summary corrections on the effect of surface radius on Rockwell hardness are determined by averaging correction data available from literature tabulated. The minimum hardness unit was taken as 0.5. J. H. Palm, Holland

1114. **Driscoll, D. E., The Charpy impact machine and procedure for inspection and testing Charpy V-notch impact specimens,** *ASTM Bull.* no. 191, 60–64, July 1953.

The principal objects of this paper are (1) to summarize effects which variables in specimen geometry and testing procedures may produce on the results of notched-bar impact tests, and (2) to describe the procedure used at the Watertown Arsenal Laboratory in the inspecting and testing of standard V-notch Charpy impact-test specimens.

In order to accomplish these, the various steps to obtain impact-test values have been considered in detail, pointing out features that could cause incorrect values. After exhaustive tests using the Charpy machines at the Watertown Arsenal Laboratories and after cooperative work with other Ordnance establishments and private testing facilities, it is author's conclusion that, if the Charpy impact machine is in proper working condition, the specimens are properly machined, and, if the personnel are trained to understand the importance of testing techniques and to follow these techniques, the machines should produce reliable results. Under these conditions, variable results should be due to variation in the material characteristics of the specimens tested.

From author's summary by A. F. C. Brown, England

1115. **McSkimin, H. J., Measurement of elastic constants at low temperatures by means of ultrasonic waves. Data for silicon and germanium single crystals, and for fused silica,** *J. appl. Phys.* **24,** 8, 988–997, Aug. 1953.

The data mentioned in title are obtained by ultrasonic shear and compressional waves in the 10–30 mc range at temperatures between 78 and 300 K (1.6 to 300 K for fused silica). The waves are transmitted from the crystal source down a fused silica rod through a quarter wave-length seal into the solid specimen.

F. E. Borgnis, USA

1116. **Glaubitz, H., Measurement of rolling strength of materials** (in German), *ATM* no. 210, 151–152, July 1953.

Author has compiled short descriptions of hitherto used testing methods of the rolling strength. The major obscurity in such methods, namely the lack of a strict criterion of the primary rupture in surface material, is not treated. R. Nilson, Sweden

1117. **Freudenthal, A. M., and Gumbel, E. J., On the statistical interpretation of fatigue tests,** *Proc. roy. Soc. Lond.* (*A*) **216,** 1126, 309–332, Feb. 1953.

Statistical distribution function is derived for scatter in cycles to failure in specimens run at constant level of alternating stress. Since failure is caused by the weakest of a very large number of elements making up the specimen, an asymptotic extreme value distribution is obtained. One can, therefore, disagree, as does the reviewer, with the physical assumptions and the derivation of distribution of lives of the elements and yet concur with the final result.

In applying theory, authors seem to overlook the fact that even with 20 specimens, parameters obtained are only point estimates, with no indication of how far from those estimates the true parameters may be. Thus the intersections of survivorship functions for different stresses (pp. 329–330) may be due to statistical causes alone. Reviewer feels work on confidence limits for the estimation of parameters of this distribution is essential to practical application of the theory to large as well as small samples.

F. A. McClintock, USA

1118. **v. Hámos, L., An x-ray microanalyzer camera,** *Trans. roy. Inst. Technol., Stockholm* no. 68, 68 pp., 1953.

When an object capable of emitting x rays is irradiated by primary x rays and its secondary radiation is directed at the concave side of a cylindrical mirror formed by a bent crystal, secondary rays are reflected and focused by it, forming a true monochromatic image of the emitting surface. This focusing effect can be used for magnifying the x-ray images. An apparatus incorporating this arrangement permits determining the thickness of very thin layers accurate to 2% and requiring areas measuring only fractions of a millimeter, the composition of alloys using 10^{-8} to 10^{-7} cc samples, and variations of concentration of any single element over the surface of a specimen, for example, of segregation of Cu in an Al-Cu alloy or of Cr in a chromium steel. A microanalyzer camera for this work, its operation, and preparation of crystal mirrors are minutely described. The theory underlying the method is exhaustively treated. Thirty-seven references are listed. J. D. Gat, USA

Mechanical Properties of Specific Materials

(See also Revs. 1074, 1097, 1107, 1108, 1115, 1118)

1119. **Carr, A. L., and Steven, W., Impact properties of annealed spheroidal-graphite cast iron,** *Metal Treatm.* **20,** 97, 455–461, Oct. 1953.

Article presents briefly some of the characteristic impact behavior of spheroidal graphite irons containing some residual magnesium and predetermined amounts of manganese silicon and phosphorus. The nature of fracture, transition temperature, and actual impact values are given for a considerable number of alloys. In the summary table the Brinell hardness and tensile properties are also given. While the addition of manganese and silicon increased the hardness, it lowered the impact values and raised the transition temperatures. Small amounts of phosphorus did not change the picture, but phosphorus content of 0.3% and more reduce the impact value and raise the transition temperature.

R. G. Sturm, USA

1120. **Dreves, F. E., The effects of cold-drawing, microstructure, and thermal treatments on the machinability and mechanical properties of carbon and alloy steel,** *Trans. ASME* **75,** 7, 1219–1232, Oct. 1953.

The purpose of this paper is to describe the role of the cold-finished steel mill in the field of metal cutting. With constant advances in machining techniques, the mill is looked upon to supply more closely controlled material to meet the demands of the production engineers and machinists. Production engineers are now more conscious of metal-cutting economics than ever before. They are confronted with innumerable factors that affect machinability. However, they desire more knowledge of the tangible factors, such as the material and how it will affect their production, including secondary operations such as cold-crimping, heat-treating, and so forth. Where cold-finished steel bars are concerned, there are several ways such bars can be produced, one of which may be the most suited for a particular application. The

cold-finishing operations are described briefly. The effects of cold-drawing on the machinability and mechanical properties of some common grades of steel are explained. Microstructure plays an important role in the machining of all grades of steel. Its effect on the machinability of plain-carbon grades and medium-carbon constructional alloy grades is discussed, along with the common thermal treatments employed to control it. The advantages of stress-relieving for certain applications are mentioned. From author's summary

1121. Melcon, M. A., Ultra high strength steel for aircraft structures, *Prod. Engng.* **24,** 10, 129–141, Oct. 1953.

During the past three years a comprehensive research and test program was carried out to evaluate the properties of SAE 4340 steel heat-treated to strength levels much higher than those conventionally used in aircraft structures. This investigation shows that SAE 4340 steel heat-treated to 260,000–280,000 psi is suitable as an aircraft structural material. Included are the results from tests to establish static, impact, and fatigue properties; notch sensitivity characteristics, fabricating and processing techniques, including machining, welding, and finishing.

From author's summary

1122. Jackson, J. H., Slunder, C. J., Harder, O. E., and Gow, J. T., Resistance of cast Fe-Cr-Ni alloys to corrosion in oxidizing and reducing flue-gas atmospheres, *Trans. ASME* **75,** 6, 1021–1034, Aug. 1953.

See AMR 6, Rev. 2245.

1123. Dick, W., Properties of rimming low-carbon basic Bessemer steel after having been water-hardened from rolling temperatures (in German), *Stahl u. Eisen* **73,** 15, 945–966, July 1953.

1124. Loizou, N., and Sims, R. B., The yield stress of pure lead in compression, *J. Mech. Phys. Solids,* **1,** 4, 234–243, July 1953.

Variations of the yield stress of pure lead in uniaxial compression with temperature, strain, and strain rate are discussed. Investigations to test the accuracy of the results have been made. Two plastometers, one for a constant speed of compression and one for constant strain rate, were used. An average coefficient of friction between the platens and specimen has been measured for lubricated and unlubricated compression. Experiments from 0 C to 110 C and from 0.8/sec to 20/sec strain rate could be performed. The results seem to indicate that the yield stress is dependent not only on the instantaneous temperature, strain, and strain rate but also on the total time to deform the specimen from annealed condition, on the rate of deformation, and on the time required for recovery and recrystallization.

R. K. Bernhard, USA

1125. Cupp, C. R., Gases in metals, *Progress in Metal Physics* **4,** 105–173, 1953; New York, Interscience Publishers.

Author surveys the literature on gases in metals, dealing first with the relations between solubility, compound formation, and diffusion. The following effects of dissolved gases are considered: Internal friction, electronic work function, changes in lattice parameters, magnetic properties, electrical resistivity, ionic conductivity, specific heat, mechanical properties, including the yield point, internal oxidation, and embrittlement. Author lists 191 references, with a supplementary list of 45 references on porosity, unsoundness, and degassing, and 12 general references.

F. R. N. Nabarro, South Africa

1126. Reggiori, A., and Erra, A., Characteristics of metals at high temperatures (in Italian), *Termotecnica* **7,** 7, 279–289, July 1953.

Several time-elongation curves are reported for alloy steels of the types 18 Cr, 8 Ni, 4.5 W, 2 Si and 18 Cr, 8 Ni, 4 W. Tests were carried out at various temperatures up to 800 C and the effect of previous heat-treatments also investigated. Graphical representation includes speed of elongation of steel 0.80 Cr, 0.30 Mo, and fatigue tests at elevated temperatures. Equipment used and microstructures are illustrated. A. O. Schmidt, USA

1127. Kozacka, J. S., Erickson, H. A., Highriter, H. W., and Gabriel, A. F., An investigation of cemented tungsten carbide as bearing material, *Trans. ASME* **75,** 7, 1203–1209, Oct. 1953.

See AMR 6, Rev. 2666.

1128. Massengale, G. B., Mong, L. E., and Heindl, R. A., Permeability and some other properties of a variety of refractory materials: I, *J. Amer. ceram. Soc.* **36,** 7, 222–229, July 1953.

Flatwise, edgewise, and endwise permeabilities, bulk densities, moduli of elasticity, and porosities were determined for the following types of refractory brick as received from the manufacturers: fire-clay, insulating, mullite, silica, kaolin, high-alumina, acid-proof, magnesite, unburned magnesite-chrome, and unburned chrome-magnesite. These properties were also determined for specimens (1) of the unburned brands of the chrome-magnesite and magnesite-chrome brick after heat-treating at 925 and at 1600 C, (2) from the side wall of a clay pot after heat-treating at several temperatures, and (3) from the side walls of two other pots and the bottom of one after heat-treating at 1400 C only. For refractory brick, flatwise permeability was least and edgewise greatest; permeability was not closely related to the other determined properties. Sintering caused larger increases in the permeability than the (partial) decomposition of the chemical binder of unburned basic brick. Of the determined properties of specimens cut from the pots, permeability was the most sensitive to heat-treatment and was the best criterion of resistance to molten glass. Permeability, modulus of elasticity, and bulk density increased, whereas bulk volume and porosity decreased with successively higher heat-treatments for the pots.

From authors' summary

1129. Kleinschmidt, L. R., Preparation of bituminous films by spinning, *ASTM Bull.* no. 193, 53–55, Oct. 1953.

A method is described for the preparation of test coatings by spinning of asphalts, coal-tar pitches, and other solid materials not having fixed melting points and which will liquefy under 450 F. The method was most effective where a series of coatings was required, varying by small increments in thickness. A large number of test specimens can be prepared from a minimum quantity of material in a relatively short time, since no cleanup is required during the coating operation. Coating thicknesses are controlled chiefly by the temperature of the material and the speed of rotation of the test disk. Coatings have been prepared by this method from blown petroleum asphalts in thicknesses ranging from 0.0005 to 0.05 in. From author's summary

1130. Greenfeld, S. H., A method of preparing uniform films of bituminous materials, *ASTM Bull.* no. 193, 50–53, Oct. 1953.

A hydraulic press was adapted to the preparation of uniform films of both stabilized and unstabilized bitumens for exposure out of doors and to accelerated durability tests. Films in the range of 0.005 to 0.050 in. were made consistently within a maximum variation of ±0.001 in. in each film, with fewer than

10% rejections. Coatings up to 0.100 in. thick can also be made. From author's summary

1131. **Denny, D. F., The influence of load and surface roughness on the friction of rubber-like materials,** *Proc. phys. Soc. Lond.* (*B*) **66,** 405, part 9, 721–727, Sept. 1953.

The friction of nine rubber compounds and two gelatine-based solids was measured against various lubricated track surfaces. When the rubberlike material was rubbed against smooth hard surfaces at a uniform velocity of 0.01 cm sec^{-1}, friction was shown to be dependent on the law $1/\mu = A(1 + pB/E)$ where p is load per unit area of specimen, μ coefficient of friction, and E the compression modulus. The value of the coefficient A was shown to be characteristic of the particular combination of material and lubricant under test and varied over the range of 1 to 8. B remained substantially constant at an average value of 15. This result is in conformity with Thirion's formula and is consistent with the hypothesis that friction is proportional to true area of contact.

Experiments were also carried out in which smooth specimens of Hycar 90 were slid on surfaces of perspex (methyl methacrylate) which had been roughened by emery to give a range in surface finish from 0.01 to 1.62 center-line average roughness (microns). At all loads frictional force was shown to increase with roughness. The author concludes that track roughness introduces an additional friction force unrelated to contact area but dependent on intensity of loading. Such a force might originate in the energy required to tear out material in the path of track asperities or, alternatively, in the hysteresis accompanying stress-reversals in the rubber as it deforms elastically in conformity with the undulating surface. F. T. Barwell, Scotland

1132. **Clinebell, Betty Jo, and Straka, Leora E., Engineering developments of rubber, 1951–1952,** *Mech. Engng., N. Y.* **75,** 8, 632–638, Aug. 1953.

1133. **Weir, C. E., Thermodynamics of the rubber-sulfur system at high pressures,** *J. Res. nat. Bur. Stands.* **50,** 6, 321–327, June 1953.

Previously reported pressure-volume-temperature data on rubber-sulfur vulcanizates are subjected to thermodynamic calculations to provide the work, heat, and internal energy change associated with compression, and the difference between the specific heats at constant pressure and at constant volume. It appears that at the glass transition there is no discontinuity in the heat capacity at constant volume. J. D. Ferry, USA

1134. **Weir, C. E., Second-order transitions of rubbers at high pressures,** *J. Res. nat. Bur. Stands.* **50,** 6, 311–319, June 1953.

Pressure-volume-temperature data on rubber-sulfur vulcanizates (1000 to 10,000 atm, 10 to 80 C, 10 to 28% sulfur) are analyzed with special attention to the discontinuity in thermal expansion coefficient (the second-order transition). There is no measurable change in transition temperature with pressure; no noticeable discontinuity in compressibility at the transition temperature; and no isothermal transition produced by pressure. Contrary conclusions from earlier data are critically discussed.
J. D. Ferry, USA

1135. **Weir, C. E., Temperature dependence of compression of natural rubber-sulfur vulcanizates of high sulfur content,** *J. Res. nat. Bur. Stands.* **50,** 3, 153–160, Mar. 1953.

Measurements are reported of the bulk compression of rubber-sulfur vulcanizates in the temperature range 10 to 81.5 C between pressures 1000 and 10,000 atm. Sulfur contents varied from 10 to 28%. Empirical isobaric equations are derived for specific volume. From the isobars, empirical equations of state (pressure-volume-temperature) are derived.
From author's summary by J. D. Ferry, USA

1136. **Lindberg, J., Relationship between various parameters of a load-elongation curve,** *Textile Res. J.* **23,** 10, 683–689, Oct. 1953.

This paper involves a statistical analysis of the relationship between various parameters on load-elongation curves for wool fibers in order to find low-variance single-fiber mechanical properties. No consideration is given the functional significance of these properties.

The Hookean slope and the force at 20% elongation in the wet state were found to be independent of each other for one particular sample of fiber. The area under the curve up to 20% elongation was found to be dependent upon both the Hookean slope and the force at 20% elongation, and it is therefore unnecessary to determine this area if the latter two parameters are known.
From author's summary

1137. **Hammerle, W. G., and Montgomery, D. J., Mechanical behavior of nylon filaments in torsion,** *Textile Res. J.* **23,** 9, 595–604, Sept. 1953.

The stress relaxation of 30-denier drawn nylon filaments was observed and found to be approximately linearly related to log time over periods from 20–20,000 sec after twisting. On the basis of this result, the behavior of the filament in torsional vibration was predicted and the predictions were tested experimentally with a torsional pendulum of period 50–400 sec. Reasonably good agreement was obtained. Stress relaxation in linear extension was also measured over periods 10–2000 sec after stretching. Quantitative correlation between extensional and torsional measurements could not be obtained because of the anisotropy of the material. H. Kolsky, England

1138. **Gralén, N., Olofsson, B., and Lindberg, J., Measurement of friction between single fibers. Part VII. Physicochemical views of interfiber friction,** *Textile Res. J.* **23,** 9, 623–630, Sept. 1953.

The subtitle of this paper is misleading, as no true physicochemical views are expressed. Paper deals with mathematical analysis of the twist friction meter developed by the authors for a study of interfiber friction. It is shown from extensions of Herz' theory that the frictional force between two fibers $F = \alpha W + \beta lR$, where W is the load, l, R are dimensions of the loaded cylindrical fibers, and α and β are constants depending on the elastic and plastic properties of the material. Formula is shown to give a good description of results of tests on nylon and "Terylene" polyester fibers. Values of the sheer strength and yield pressure derived from the results are stated to be of the correct magnitude, though for nylon the value of the shear strength is $^1/_{70}$ of the usually quoted figure. K. W. Hillier, England

Mechanics of Forming and Cutting

(See also Revs. 1098, 1120)

1139. **Witthoff, J., Carbide tools for machining metals** [**Die Hartmetallwerkzeuge in der spanabhebenden Formung**], München, Carl Hanser Verlag, 1952, 223 pp. DM 16.

Contemporary metal-cutting practice and carbide tooling are presented for the benefit of the production and tool engineer.

Application of carbide tools for the machining of manganese steels and hard castings is supported by experimental and production data regarding economical operations and maintenance. Grinding and required properties of grinding wheels are illustrated. Data on machining and tool shapes are also furnished for plastics and light metals as well as for deep hole drilling, threading, and reaming. German recommendations for tool angles, types of carbide, cutting speed, feed, and tool life are listed in tabular form for various engineering materials. A. O. Schmidt, USA

1140. Rayburn, F. M. Machining of high-tensile-strength steel, *Mech. Engng., N. Y.* **75,** 10, 794–795, 798, Oct. 1953.

1141. Purchase, N. W., and Tupper, S. J., Experiments with a laboratory extrusion apparatus under conditions of plane strain, *J. Mech. Phys. Solids* **1,** 4, 277–283, July 1953.

Experiments are described in which a rectangular block of commercial lead was extruded in a small-scale extrusion press. For the range considered, 10 to 90% reduction, the pressures obtained were in excellent agreement with the theoretical analysis of Hill [see AMR **1,** Rev. 847]. The deformation of an initially squared grid inscribed on the billet was also, generally speaking, in good agreement. B. W. Shaffer, USA

1142. Hill, R., On the mechanics of cutting metal strips with knife-edged tools, *J. Mech. Phys. Solids* **1,** 4, 265–270, July 1953.

This article gives a mathematical analysis of the stresses and plastic flow that occur during the cutting of metal strips with knife-edged tools. The operation is identically similar to the one known in the stamping industry as "dinking." The analysis includes the effects of varying friction and included angle of the knife for a nonwork-hardening material. However, the solution permits a qualitative evaluation of the effect of work hardening.

Results of the analysis predict that the metal flow will be uniform for knife-edge included angles equal to or less than 44° 20 min where the limiting angle is determined for zero coefficient of friction. The theory also predicts the formation of a dimple as a result of tensile necking on the underside of the sheet opposite the knife edge when the perimeter of the sheet is not constrained. The predictions are confirmed by experimental results. This article gives an interesting application of the mathematical theory of plasticity. L. V. Colwell, USA

1143. Grechukhin, A. I., Effect of the cutting edge sharpness on the quality of surface in metal work (in Russian), *Stanki i Instrument* no. 5, 23–25, May 1953.

Radius at cutting edge was taken as a measure of tool sharpness for experiments described. A 40-ton vertical broaching machine with 5-teeth broaching insets was used because of some obvious advantages. Only 2 teeth were cutting. Tooth form was: top rake 20°, clearance angle 2°. Insets were made from P. 18 steel of R_c62–64. Cutting-edge radius varied from 0.000275 to 0.00197 in. by hand honing and was measured on an MIS-11 bifocal microscope. Tooth surface finish was to 5.9 microinches on top face and 11.8 microinches on clearance face. Depth of cut varied from 0.00039 to 0.00197 in. per tooth. Cutting speed was 3.28 fpm, and a sulfurized mineral oil was used as coolant. Samples were made from an alloy steel, 2X13, with a considerable chromium content. Effect of cutting-edge sharpness and depth of cut on surface roughness and depth of compressed outer layer of metal were determined.

It is stated in conclusion that cutting-edge sharpness has a marked influence on roughness and depth of compressed layer. Increasing the cutting-edge radius from 0.000275 to 0.00197 in. may nearly double the surface roughness and increase compressed layer depth by 50 to 60%. The depth of cut is stated to also have an appreciable effect on surface roughness, while cutting speed and tooth geometry show a much lesser influence. Three graphs and four photographs are given.

J. H. Dziewonski, England

1144. Škrigatić, M., From the theory of the cutting and machining of metallic material (in Serbian), *Tehn. Pregl.* **5,** 3, 107–117, 1953.

In metal-machining theory an attempt is made to give a uniform term for the economic cutting speed. After a historical review of the research results, author considers all the facts influencing the economical speeds. There are numerous data about tools and speeds. Based on the newest researches, the author gives his conclusions and the evolution of a mathematical formula which satisfies different sorts of materials fairly well. It is interesting that the formula is nearly universal because the functional relation of the economical speed and the strength of the material and also the feed remained similar for the machining of the light metals. The article includes graphical and numerical comparative data, which show clearly that they are in accordance with practical results. From author's summary

1145. Lemcke, G., Electronic and magnetic control in continuous reversing rolling mill (in German), *Stahl u. Eisen* **73,** 18, 1156–1162, Aug. 1953.

1146. Schmidt, A. O., Temperature measurements of workpiece, tool, and chip (in German), *Werkstattstechnik u. Maschinenbau* **43,** 8, 345–350, Aug. 1953.

1147. Avakov, A. A., Determination of temperature during metal cutting (in Russian), *Zh. tekh. Fiz.* **21,** 10, 1262–1268, Oct. 1951.

Difficulties of theoretical and experimental methods of temperature determination at surface of cutter at high-speed cutting are stressed, and shortcomings of known methods, including Herbert's, are reviewed. "Natural" thermocouple devised by author and obtained by welding of a heavy chip to face of cutter under cutting conditions to which a thin strip of a flowing chip is arc-welded subsequently is described. Such thermocouple is used for calibration. Such method is stated to be applicable to comparatively heavy chip removal. Other methods, including use of thermocouples made from two hard alloy tips insulated from the holder (modified Reichl's method), and thermocouples brought onto the face of the cutter through a very small hole are also described. The latter method is recommended for large cutters of about $2^1/_2$ in. × $3^1/_2$ in. × 20 in. long. Results of temperature measurements are given, but opinion is expressed that these temperatures are lower than the actual temperatures of the surface layer of cutter top face. This latter is thought to be equal to the melting point of the chip at the moment of thermal failure of cutter.

The amount of heat rejected from the chip to the cutter when cutting artifically heated metals is determined by two factors: Heat transfer from the hot chip, and heat generated by friction. Opinion is expressed that cutting speeds in the range of several tens of thousands can be obtained in machining steels artificially heated to such a temperature that the decrease in specific pressure of chip on cutter face is decreased four to five times in comparison with that of the cold chip. This temperature for steels of 78,000 psi is about 850 C. J. J. Dziewonski, England

1148. **Buckley, F., Developments in steel castings in the heavy power plant industry,** *Instn. mech. Engrs. Proc.* (*A*) **167,** 2, 177–183, 1953.

1149. **Briggs, C. W., Dimensional tolerances for steel castings,** *Mech. Engng., N.Y.* **75,** 8, 619–621, Aug. 1953.

1150. **Lansing, J. H., Tolerances and specifications of malleable castings,** *Mech. Engng., N. Y.* **75,** 8, 621–624, Aug. 1953.

1151. **Sugg, R. E., An interferometer for examining polished surfaces,** *Mech. Engng., N. Y.* **75,** 8, 629–631, Aug. 1953.

Hydraulics; Cavitation; Transport

(See also Revs. 1050, 1163, 1254, 1320, 1347)

1152. **Jaeger, C., Technical hydraulics** [**Hydralique technique**], Paris, Dunod, 1954, xviii + 510 pp. 4900 Fr.

Translation from German by Marie Laronde. See AMR **3,** Rev. 712.

1153. **Escande, L., New hydraulic proceedings** (in French), *Publ. sci. tech. Min. Air, Paris* no. 280, 232 pp., 1953.

This volume presents the results obtained during the past two years by Professor Escande in his work on various research projects. Chap. I discusses problems of similitude applied to sand dunes. Chap. II deals with the possibility of studying ship models in the jet issuing from a sluice gate. Chaps. III to VII treat of hydraulic problems related to dams: Flood disposal in high dams, studies on rock-fill dams, ventilation of the nappe in movable dams, adjustable shutter-type spillways, Creager-type spillways. In chaps. IX to XVII, a complete analysis is given of surge tanks with restricted orifice, which are increasingly used in hydroelectric power installations using large rates of flow under medium or low heads.

This grouping of various studies in advanced hydraulics, following two previous volumes of the same nature, reflects the versatility of their author, his acute sense of analysis of hydraulic phenomena, and his ability to expose clearly a difficult subject.

A. L. Jorissen, USA

1154. **Weske, J. R., and Plantholt, A. H., Discrete vortex systems in the transition range of fully developed flow in a pipe,** *J. aero. Sci.* **20,** 10, 717–718, Oct. 1953.

Investigation was made to obtain insight into process by which unidirectional vorticity of laminar flow is transformed and augmented in omnidirectional vorticity of turbulent flow. Expressions are given for lift on a vortex filament (Magnus effect) and for conversion of energy of mean flow into energy of discrete vortex filaments by stretching of vortex filaments.

Formation of vortex filaments was induced experimentally by placing trips of various designs in a fully developed pipe flow (Reynolds number ~2000). Trips formed succession of horseshoe vortex filaments which were stretched as they passed downstream. Vortex filaments had radial as well as axial components.

R. G. Deissler, USA

1155. **Shevelev, Ya. V., Poiseuille's flow in nonsymmetrical radial clearance; analogy with the torsion of beams** (in Russian), *Dokladi Akad. Nauk. SSSR* (*N.S.*) **91,** 1, 35–38, 1953.

Kuznetsov (1952) obtained the erroneous result that the laminar resistance of cylindric tubes can be diminished by inserting an eccentric inner tube. Author therefore investigates the exact solution of the laminar flow through the annular space of two eccentric tubes. The problem follows the same differential equation as the torsion of a beam with the same annular cross section. The known solution of the latter problem by Macdonald (1894) is applied, using bipolar coordinates. Also the cases of the inner or outer tube moving in axial direction are considered. A graph shows the dependence of the flow quantity and also of the torsional stiffness from the ratio of radii and eccentricity.

W. Wuest, Germany

1156. **Dadenkov, Yu. N., Determining the loss of pressure in canals and pipes** (in Russian), *Gidrotekh. Stroit.* no. 6, p. 33, June 1953.

1157. **Supino, G., Air-water analogy and the study of hydraulic models,** *NACA TM* 1359, 22 pp., July 1953.

See AMR **5,** Rev. 2079.

1158. **Benedict, P. C., Albertson, M. L., and Matejka, D. Q., Total sediment load measured in turbulence flume,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 230, 49 pp., Aug. 1953.

Model and prototype investigation of use of baffles, on paved channel under a bridge, to suspend the bed load silt so samples taken by the usual method would indicate the total sediment load. Staggered baffle arrangement with downstream measuring sill worked satisfactorily.

J. C. Geyer, USA

1159. **Numachi, F., Cavitation tests on hydrofoils in cascade,** *Trans. ASME* **75,** 7, 1257–1269, Oct. 1953.

See AMR **6,** Rev. 3535.

1160. **Willard, G. W., Ultrasonically induced cavitation in water: a step-by-step process,** *J. acoust. Soc. Amer.* **25,** 4, 669–686, July 1953.

Through the use of improved experimental technique, results are obtained which are of fundamental importance to better understanding of the inception in nature of the process of cavitation. By focusing the radiation from a 2.5-mc source into a narrow elongated region and taking advantage of the use of traveling waves to induce the streaming of the water through the high intensity region (a pressure amplitude of 70 atm is obtained in the focal region), close observations were made of the details of the time history of the cavitation process. These observations were facilitated by the use of high-intensity illumination and high-speed photographic recording. The results indicate that cavitation proceeds through a definite sequence of phases, each phase requiring the completion of the previous one.

The action is apparently triggered by the passing of some microscopic defect into the focal region. This, designated (0) the preinitiation condition, is not actually observed but is postulated because of the sporadic repetition of the process and the fact that the stresses due to the sound beam are well below the ultimate tensile strength of the water. The first observation is the appearance of a very small oscillating cavity growing slowly and steadily until resonant size is reached. The discovery of this (1) initiating phase, which requires between 200 to 2000 cycles, i.e., 0.1 to 0.8 msec, and the necessity of its completion before the characteristic cavitation burst can proceed are quite significant. It explains, for example, why greater intensity is required to produce visible cavitation when a pulsed source is used.

Upon attaining resonant size, the vibrations of the cavity suddenly are no longer sinusoidal but become violent pulsation, much like those of the cavity produced by an underwater explosion, and

appear to radiate shock waves of sufficient amplitude to open clouds of microcavities. This (2) catastrophic phase continues until the pulsing cavity passes out of the focal region.

Another important fact revealed by these experiments is that the occurrence of these phases is unaffected by the air content of the water. With air-saturated water the catastrophic phase is accompanied with the formation of some noncollapsing gas bubbles at the edge of the cavity. The formation of gas bubbles is reduced when the concentration of air in the water is reduced and this (3) bubble phase is entirely eliminated by reduction of the air concentration to $^1/_6$ of saturation. When gas bubbles are formed they move downstream, their numbers increasing with each burst, thus forming (4) the postcavitation condition.

There is some discussion of the applicability of available theories for describing the cavity pulsations. However, in connection with the present work the nature of the defects, i.e., nucleii which trigger the action, seems to present the more interesting questions. Information regarding the frequency and strength of nucleii and the effect on these of conditioning the water might be obtained from similar experiments.

Reviewer notes a striking resemblance between the history of the cavitation process and the results described in his paper [*David W. Taylor Mod. Basin Rep.* 853, May 1953] for the growth of an air bubble by rectified diffusion in a weak sound beam. In the latter case, an initially very small bubble also grows steadily at a large relative but moderate absolute rate, and an abrupt and considerable increase in the rate of growth when resonance is reached is indicated. Perhaps the initiating phase could be explained by an analogous process, in this case the radiation-excited oscillations upsetting the usual equilibrium relationships between liquid and vapor. L. Pode, USA

1161. Bloch, P., Theoretical and experimental investigations of a hydraulic transmission (in German), ETH Zurich, Thesis no. 2116, 74 pp., 1953 = *von Roll Mitteilungen* **12,** 1/2, Jan.-June 1953.

Paper is a thorough and clear discussion of the characteristics of the axial-piston (variable), positive-displacement hydraulic unit, known as the Thoma-Vickers machine and used as pump, motor, or two-unit transmission. The version treated permits canting of the yoke axis to reduce compressibility and other losses.

Paper gives detailed derivations and design formulas of such items as the geometry and kinematics of the drive, flow and pressure variations, pressure and leakage losses, friction and other mechanical losses, effects of compressibility and temperature, and optimum clearances and yoke-axis canting angles. Experimental results are reported for a seven-piston unit up to 1000 rpm and 3600 psi.

In view of the increasing importance of these units for servo applications, an extension of these useful results to nonsteady state conditions would be helpful. G. A. Nothmann, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 1030, 1032, 1159, 1199, 1205, 1213, 1221, 1240, 1326, 1342)

1162. Landahl, M. T., and Stark, V. J. E., An electrical analogy for solving the oscillating-surface problem for incompressible nonviscid flow, *Roy. Inst. Technol., Div. Aero., KTH Aero. TN* 34, 19 pp., 1953.

A method is suggested for solving the problem of an oscillating surface in three-dimensional, incompressible, ideal flow with the aid of an electric potential tank. A special potential function, satisfying the Laplace equation, is used and the boundary conditions are formulated in this potential. The potential problem thus obtained is very like the steady-state problem for which electrical analogies have previously been developed. The difference is that in the oscillating case the prescribed normal derivative on the surface contains a special integral over the infinite region in the plane ahead of the surface. Since this integral in turn depends on the normal derivative on the surface, the integral has to be determined by a special process. The method is used in the two-dimensional case where it is possible to check the experimental results from the analogy with the theoretical ones, and good agreement is obtained.

From authors' summary by R. L. Bisplinghoff, USA

1163. Detra, R. W., The secondary flow in curved pipes, *Mitt. Inst. Aerodyn., ETH. Zurich* no. 20, 50 pp., 1953.

Author develops linearized theory of secondary flow in pipe bends of small curvature. Secondary-flow velocity components are considered as small perturbations on the principal flow and the axial velocity is assumed not to change. Theory is developed by assuming a straight pipe and a body force, which is a function of the fluid particles' axial velocity, acting such that it corresponds to the centrifugal force present for a given curved pipe. Since theory neglects effect of large velocity gradients, it requires that ratio of wall to axial velocity in inlet distribution be taken as finite. By assuming appropriate values of this ratio, it is shown that general character of secondary velocity distributions, obtained from experiments with two bends of different (small) curvature and four different inlet velocity distributions, is exhibited by results of theory. Using this theory, losses in bends of circular and elliptic cross section are compared for the same wall to axial-velocity distribution. It is shown that the losses are smallest for the elliptic section oriented so that the minor axis lies in the plane of the bend. This result may be generalized to any symmetrical, noncircular section, i.e., losses will be smallest when the largest dimension is normal to the direction of the centrifugal force. P. Eisenberg, USA

1164. Stanitz, J. D., Osborn, W. M., and Mizisin, J., An experimental investigation of secondary flow in an accelerating, rectangular elbow with 90° of turning, *NACA TN* 3015, 60 pp., Oct. 1953.

A 90° elbow was designed for accelerating velocities without separation. The secondary flow was investigated with six boundary-layer thicknesses generated with spoilers placed upstream from the bend. Complete surveys were made for each spoiler size. The data were analyzed using the continuity and momentum laws.

It was found that the vortex changed with spoiler size, and it was felt that the changes were related to the reduced importance of viscosity with the thicker boundary layers. The tests indicated that the strength of the secondary vortexes is small and that the energy of the secondary flow is small.

G. N. Cox, USA

1165. Silberman, E., Importance of secondary flow in guide vane bends, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 669–686, 1953.

Paper presents an experimental investigation of secondary flow in 90° guide-vane bends. Data are presented for three vane profiles tested over a range of guide-vane solidity. In agreement with the work of Eichenberger [Eichenberger, H. P., "Shear flow in bends," ONR TR no. 2, Contract N5 ori 07848, Gas Turbine Lab., M.I.T., 1952], it is shown that the major losses due to secondary flow occur downstream from the vanes and are caused by the increased wall shear resulting from the transport, by

secondary flow, of high velocity fluid from the main stream to the duct walls downstream of the vanes. The paper points out the small effect of secondary flow on the deflection of the main stream but ignores the important effect of secondary flow on the deflection angle near the end walls.

The experimental results are noteworthy, but the physical picture of secondary flow presented in the paper adheres to the outdated concepts of Carter and Cohen [Carter, A. D. S., and Cohen, Elizabeth M., "Preliminary investigation into the three-dimensional flow through a cascade of aerofoils," AMR **3**, Rev. 2478].

J. D. Stanitz, USA

1166. **Stojanovic, D., Generalization of the energy equation solution for some rotationally symmetrical laminar flows,** *J. aero. Sci.* **20**, 10, 727–728, Oct. 1953.

1167. **Hasimoto, H., On the flow of a viscous fluid past an inclined elliptic cylinder at small Reynolds numbers,** *J. phys. Soc. Japan* **8**, 5, 653–661, Sept.-Oct. 1953.

The steady plane flow problem is treated on the basis of Oseen's linearized equation of motion using elliptic coordinates and Mathieu functions. New formal solutions for the stream function are obtained. As work involved in numerical evaluation of lift and drag would be considerable, author determines expansion formulas for lift and drag at small Reynolds numbers R correct to the order of $O(R^2)$. These formulas coincide with not yet published results found by I. Imai using complex variables.

H. Görtler, Germany

1168. **Hanin, M., Generation of vortices behind a flat plate,** Grad. School Aero. Engng., Cornell Univ., Ithaca, N. Y., 55 pp., July 1953.

The development of a vortex street behind a two-dimensional flat plate is examined on the basis of potential-flow theory by assuming that the vortex sheets roll up until the Kutta condition is violated at one edge. The rolled-up vortex then detaches from that sheet and passes downstream as a discrete vortex, while the other sheet continues to roll up. The average strength of the vortex sheets and the parameters of the vortex street are estimated for the case of 90° incidence by means of (1) a time-averaged Kutta condition, (2) the vanishing of velocity at the edges of the plate on the low-speed side of the vortex sheets, (3) a momentum transfer equation, and (4) a vorticity transfer equation. The last of these involves an empirical factor (of about 0.5) ascribed to a loss of vorticity. Reviewer believes a better approximation might be obtained by assuming strength of rolled-up portion of sheets to vary as time to the two-thirds power as shown by Anton [Anton, Leo, "Ausbildung eines Wirbels an der Kante einer Platte," *Ing.-Arch.* **10**, 411–432, 1939], rather than as time to the first power.

A. H. Sacks, USA

1169. **Rosenhead, L., Vortex systems in wakes,** Advances in appl. Mech., III, 185–195, 1953. [Academic Press, Inc., N. Y.]

A critical summary of knowledge and ignorance, theoretical and experimental, of a classical phenomenon. Reader may add new papers by G. D. Birkhoff [AMR **6**, Rev. 3799] and A. Roshko [*NACA TN* 2913, Mar. 1953] to author's bibliography. A more extensive, less discriminating bibliography is in Krzywoblocki [AMR **6**, Rev. 2839].

M. V. Morkovin, USA

1170. **Donoughe, P. L., and Prasse, E. I., Pressure distributions about finite wedges in bounded and unbounded subsonic streams,** *NACA TN* 2942, 41 pp., May 1953.

Analytical investigation of incompressible flow about wedges was made to determine effects of tunnel-wedge ratio and wedge angle on wedge pressure distributions. Region of applicability of infinite wedge-type velocity distribution was examined for finite wedges. Theoretical and experimental pressure coefficients for various tunnel-wedge ratios, wedge angles, and subsonic Mach numbers were compared.

From the authors' summary by J. A. Lewis, USA

1171. **Stewartson, K., A weak spherical source in a rotating fluid,** *Quart. J. Mech. appl. Math.* **6**, part 1, 45–49, Mar. 1953.

Author considers problem of a weak spherical source (efflux velocity at surface is small) placed on axis of a body of perfect fluid in solid rotation. The solution of the linearized equations by Laplace transforms yields the pattern of the ultimate flow in addition to other results obtained previously by S. F. Grace [*Proc. roy. Soc.* (*A*) **105**, 532, 1924]. The solution is taken, in part, from another paper by same author [AMR **5**, Rev. 1787], which treats the case of a sphere moving slowly along the axis of rotation of the surrounding fluid.

The ultimate flow (a long time after source began to emit) is divided into two regions by the circular cylinder circumscribing the source whose axis coincides with the axis of rotation. The perturbation streamlines within this cylinder are straight and parallel to the axis, so that entire efflux of source is contained in the cylinder. Outside the cylinder the perturbation streamlines are concentric circles with the sense of the flow opposite to initial rotation. Both flows are independent of time and the velocities decrease rapidly with distance from the surface of the cylinder. On the cylinder, with the equator of the source expected, both axial and azimuth velocity components grow indefinitely as $(time/axial\ distance)^{1/2}$.

In addition, author finds (as did Grace) that on the axis of rotation the axial-velocity component oscillates finitely about a mean value equal to velocity of efflux from source. On the sphere (again equator excepted) the velocity components are oscillatory. On the equator the axial velocity is zero, the radial velocity is equal to velocity of efflux, and the negative azimuth velocity grows indefinitely with time.

Reviewer notes that some of the results (e.g., oscillatory velocity along axis, or infinite velocities on cylinder) appear improbable from physical considerations. These results are perhaps due to the linearization of the equations.

J. Levy, USA

1172. **Loĭtsianskiĭ, L. G., Propagation of a whirling jet in an infinite space filled with the same fluid** (in Russian), *Prikl. Mat. Mekh.* **17**, 1, 3–16, Jan.-Feb. 1953.

The laminar flow resulting when a jet emerges from a pipe of very small diameter into an infinite space, filled with the same fluid, has been treated by L. Landau [L. Landau and E. Lifschitz, "Mechanics of continuous media," Gosud. Izdat. Tekh. Teor. Lit., Moscow-Leningrad, 1944, §19] and recently by Rumer [AMR **5**, Rev. 3133] in the case of a pipe of finite diameter. The paper under review is concerned with the case of a whirling jet. The main difficulty of this problem is caused by the presence of a pressure field due to the existence of centrifugal forces in a whirling jet. Asymptotic expansions are sought for the velocity components and the pressure in terms of negative powers of the distance of a cross section of the jet from the mouth of the pipe measured along the axis of the jet. The coefficients of the first terms of these expansions satisfy a nonlinear system of ordinary differential equations with variable coefficients. For a weakly whirled jet, this system is of separable type with respect to the unknown coefficients and integrable in a finite form. The solution obtained for a laminar jet is generalized to the case of a

turbulent one. Some general conclusions are made as to the propagation of weakly whirled jets.

E. Leimanis, Canada

1173. Thom, A. S., Design of a right-angled bend with constant velocities at the walls, *Aero. Res. Counc. Lond. curr. Pap.* 135, 18 pp., Feb. 1952, published 1953.

By the hodograph method, the shapes of the walls of the corner of a duct, in which an airfoil has been inserted, are designed so that the velocities at the walls are constant. The airfoil has the same leading and trailing halves. The fluid is assumed to be incompressible and inviscid. Two examples are given.

S. I. Pai, USA

1174. Rusanov, B. V., Slow unsteady flow of a viscous fluid around a sphere (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **90,** 1, 41–44, 1953.

Paper solves the unsteady Stokes-flow problem for a sphere by Laplace transformation techniques and obtains Boussinesq's classical formula. No new concept or result is given.

L. Trilling, USA

1175. Rusanov, B. V., Slow steady flow of a viscous fluid around a circular cylinder (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **89,** 6, 983–986, 1953.

Author gives superficial discussion of the nonuniform behavior of unsteady Stokes flow past a circular cylinder, showing that for finite initial velocities the flow decays with time.

L. Trilling, USA

1176. Karim, S. M., Second viscosity coefficient of liquids, *J. acoust. Soc. Amer.* **25,** 5, 997–1002, Sept. 1953.

The ratio μ'/μ of second viscosity to shear viscosity is determined experimentally by observing acoustic streaming in liquids (water, ethyl and methyl alcohol). A quartz crystal radiates at frequencies between 500 kc and 4 mc into a liquid-filled pyrex glass tube (4 to 8.4 cm wide and 22 to 30.5 cm long). Sound intensity is measured by a torsion balance; acoustic streaming, by observing the speed of dust particles in the liquid near the axis of the tube. The results agree (except for methyl alcohol) with theoretical and experimental results of other investigators.

F. E. Borgnis, USA

1177. Palit, S. R., Some general relations on the viscosity of homologous liquids, *Indian J. Phys.* **26,** 12, 627–636, Dec. 1952.

Compressible Flow, Gas Dynamics

(See also Revs. 1166, 1192, 1194, 1200, 1206, 1212, 1238)

1178. Shapiro, A. H., and Kline, S. J., On the thickness of normal shock waves in a perfect gas, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-35, 8 pp.

An approximate method for calculating the thickness of shocks in perfect gases, analogous to the integral methods of boundary-layer theory, is presented. An approximate velocity distribution through the shock, which agrees quite well with the known solutions, is assumed and the equations of motion and energy and boundary conditions are used to evaluate the dependence on physical properties of the fluid. Effects of Prandtl number, Mach number, and ratio of specific heats on shock thickness are evaluated. At values of the parameters for which exact solutions are known the agreement is excellent. Agreement with published experimental data is good for argon, but a systematic deviation is noted for nitrogen. A. M. Kuethe, USA

1179. Lange, A. H., Gieseler, L. P., and Lee, R. E., Variation of transition Reynolds number with Mach number, *J. aero Sci.* **20,** 10, 718–719, Oct. 1953.

The Reynolds number of transition of the boundary layer on a slender cone and on a hollow cylinder has been determined from spark-schlieren photographs at Mach numbers between 1.86 and 5.00 in the intermittent NOL 40 × 40-cm aeroballistics wind tunnel no. 2. Results are shown in the paper. Also, results and additional experimental details are given in *NAVORD Reps.* 2752 and 2823, which have been published recently. Ed.

1180. Legendre, R., Compressible two-dimensional isentropic flow (in French), *C. R. Acad. Sci. Paris* **237,** 12, 595–597, Sept. 1953.

Velocity potential and stream functions for a family of flows are expressed as real parts of contour integrals in some complex plane. The integrands involve an arbitrary analytic function of a complex variable and also a solution of a Monge-Ampere partial-differential equation. A four-parameter family of solutions of this partial-differential equation is exhibited. No applications are suggested. J. H. Giese, USA

1181. Cole, J. D., Solomon, G. E., and Willmarth, W. W., Transonic flow past simple bodies, *J. aero. Sci.* **20,** 9, 627–634, Sept. 1953.

This paper describes, in the light of recent transonic-flow theories, wind-tunnel studies of the flow about several cone cylinders and a lifting double-wedge airfoil at subsonic Mach numbers ranging upward to about 0.95 and at supersonic Mach numbers in the range from about 1.22 to 1.45. Principal attention is given to the breakdown of conical flow and shock detachment from the conical tips and the transonic behavior of the lift-curve slope and center of pressure of the airfoil. The results presented for these simple cases are valuable in clarifying some of the details of transonic flow and evaluating recent theoretical work.

J. V. Becker, USA

1182. Chester, W., Supersonic flow past wing-body combinations, *Aero. Quart.* **4,** part 3, 287–314, Aug. 1953.

The supersonic wing-body interference problem is solved under the assumptions that the body radius is much smaller than the wing chord and the wing thickness is small compared with the body radius. Velocity potentials are found which solve the linearized wave equation and boundary conditions for a wing body within the accuracy of the lower-order terms in body radius. Although the paper is entirely mathematical, a few simple results may be stated. If wing and body are at the same angle of attack, then the lift on the combination is equal to the lift on the complete isolated wing. If only the wing is at incidence, then the lift is equivalent to that on the part of the wing external to the body. It is shown also that the drag of a wing will in some cases be reduced by the interference of the body.

L. H. Schindel, USA

1183. Imai, I., On the asymptotic behaviour of compressible fluid flow at a great distance from a cylinder in the absence of circulation, *J. Phys. Soc. Japan* **8,** 4, 537–544, July-Aug. 1953.

Expressions are developed for stream function and velocity potential at large distances from arbitrary-shape, closed-contour cylinder in subsonic flow without circulation. Terms corresponding to order $1/r^5$ in velocity are included. Special application is made to case of circular cylinder. D. R. Chapman, USA

1184. Jack, J. R., Theoretical pressure distributions and wave drags for conical boattails, *NACA TN* 2972, 14 pp., July 1953.

Afterbody pressure distributions and wave drags were calculated using a second-order theory for a variety of conical boattails at zero angle of attack. Results are presented for Mach numbers from 1.5 to 4.5, area ratios from 0.200 to 0.800, and boattail angles from 3° to 11°.

The results indicate that, for a given boattail angle, the wave drag decreases with increasing Mach number and area ratio. The wave drag, for a constant area ratio, increases with increasing boattail angle. For a specific Mach number, area ratio, and fineness ratio, a comparison of the wave-drag coefficients for conical, tangent-parabolic, and secant-parabolic boattails showed the conical boattail to have the smallest wave drag.

From author's summary

1185. Van Dyke, M. D., Supersonic flow past oscillating airfoils including nonlinear thickness effects, *NACA TN* 2982, 41 pp., July 1953.

Author's summary reads: "A solution to second order in thickness is derived for harmonically oscillating two-dimensional airfoils in supersonic flow. For slow oscillations of an arbitrary profile, the result is found as a series including the third power of frequency. For arbitrary frequencies, the method of solution for any specific profile is indicated, and the explicit solution derived for a single wedge. Nonlinear thickness effects are found generally to reduce the torsional damping, and so enlarge the range of Mach numbers within which torsional instability is possible. This destabilizing effect varies only slightly with frequency in the range involved in dynamic stability analysis, but may reverse to a stabilizing effect at high flutter frequencies. Comparison with a previous solution exact in thickness [G. F. Carrier, AMR **2**, Rev. 786; M. Van Dyke, *Quart. appl. Math.* (in press)] suggests that nonlinear effects of higher than second order are practically negligible. The analysis utilizes a smoothing technique which replaces the actual problem by one involving no kinked streamlines [R. Courant and K. O. Friedrichs, AMR **1**, Rev. 661; M. Van Dyke, AMR **6**, Rev. 2854]. This strategem eliminates all consideration of shock waves from the analysis, yet yields the correct solution for problems which actually contain shock waves."

The previous treatment of second-order effects by A. Wylly [AMR **6**, Rev. 1961] is shown to be erroneous, while the semi-empirical approach of W. P. Jones [*Aero. Res. Counc. Lond. Rep. Mem.* 2679, 1947] is found to be valid only for pivot positions near midchord. The author's analysis includes only first-order terms in amplitude of oscillation (as befits a stability analysis), but a footnote indicates the differential equation governing the second-order effect in amplitude. Reviewer believes that the latter is incorrect due to the assumption of a complex, harmonic time dependence with the consequent implication that the end result is given by the real part of the complex solution (but this error does not affect any of the results given in the body of the paper).

J. W. Miles, USA

1186. Tsien, S. H., The supersonic conical wing of minimum drag, Grad. School Aero. Engng., Cornell Univ., Ithaca, N. Y., 112 pp., June 1953.

A theoretical investigation is made of thin lifting wings of the conical family, with subsonic leading edges, cambered to give minimum pressure drag at supersonic speeds. The method is an approximate one based on the linear small-perturbation theory and an approximation to the lift distribution in series form. Two different assumptions are made concerning leading-edge suction: (1) Full theoretical value of this thrust component; and (2) no thrust component, representing an extreme case of flow separation at the leading edge.

The results show that in case (1), the drag coefficient of the optimum conical wing is almost identically the same as that of a flat triangular wing, at the same lift coefficient, except when the leading edge lies close behind the Mach cone of the apex. Thus little improvement over a flat wing can be achieved, within the conical family, if full leading-edge suction is obtained. In case (2), on the other hand, substantial improvement over the flat delta wing can be achieved by suitable conical camber; in fact, the drag can be reduced to a value which is again approximately the same as that of the flat wing *with* full leading-edge suction.

The camber distributions and lift distributions of these wings are worked out and are presented in tables and charts. Appendixes include evaluation of a considerable number of definite integrals which may be useful in various related problems, and investigation of the effect on drag due to chordwise camber which gives a comparison with that due to conical camber.

From author's summary by A. H. Shapiro, USA

1187. Trilling, L., Transonic flow past a wedge at zero angle of attack, *ZAMP* **4**, 5, 358–375, 1953.

An approximate solution to the title problem is constructed by separation of the variables in the hodograph plane for the subsonic region and by the method of characteristics for the embedded supersonic region. The principal results obtained are the size and shape of the supersonic region, the position and strength of the downstream shock wave, and the pressure drag, all as functions of the transonic similarity parameter. It is stated that computed drags are less than but of the same order as the few experimental values available.

Reviewer believes the paper's value would have been considerably enhanced by a serious comparison between theory and experiment.

L. C. Woods, England

1188. Laitone, E. V., and Talbot, L., Subsonic compressibility corrections for propellers and helicopter rotors, *J. aero. Sci.* **20**, 10, 683–690, Oct. 1953.

The Prandtl-Glauert correction for the lift-curve slope is substituted in the thrust and torque equations of blade element theory and the ratio of compressible to incompressible thrust coefficient determined as function of the inflow Mach number and rotational tip Mach number. Glauert's corrections for axial and rotational interference are considered in the definition of these Mach numbers. If the blades are twisted to maintain a constant small angle of attack and the propeller is lightly loaded, the ratio of the thrust coefficients can be expressed to first order in terms of free-stream and actual rotation tip Mach number; this result is obtained by using momentum theory and is applicable for subcritical helical tip Mach numbers ($M \cong 0.80$ for thin blades). The ratio of compressible to incompressible torque coefficient is obtained in a similar way, assuming Mach number effects negligible for the torque due to blade friction. Available test data at tip speed ratios 0.765 and 0.606, C_T of 0.0095 and 0.063, respectively, show very good agreement with theory (from about $M_0 \cong 0.20$ to 0.50). Especially simple results are obtained for helicopter rotors in vertical climb. Errors in other subsonic compressible propeller theories are pointed out.

G. R. Graetzer, USA

1189. Szebehely, V. G., A measure of unsteadiness of time dependent flows, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., pp. 221–231, 1953.

The dimensionless frequency parameter or Strouhal number used in describing oscillation tests is generalized. The degree of

unsteadiness is defined as the dimensionless ratio of the absolute value of the local and convective parts of the acceleration vector. For nontrivial accelerationless flows, the value of the introduced measure of unsteadiness is one; for steady nonuniform flows, zero; and for unsteady uniform flows, infinite.

The general form of time-dependent velocity fields for which the unsteadness is constant is obtained as the solution of the Eulerian nonlinear partial-differential equations. The unsteadiness of separable (d'Alembert) flows is investigated and the criterion for time-independent unsteadiness is given.

The results are applied to the radial flow of a compressible fluid and to the unsteadiness encountered in the problem of vorticity dissipation. It is also shown that the conventional dimensionless frequency ($\omega c/2U$) is a special, linearized case of the general measure of unsteadiness introduced in the paper.

From author's summary by W. P. Jones, England

1190. Gilles, A., Nozzle profile analysis by means of the "homographic approximation" (in French), *Rech. aéro.* no. 32, 3–10, Mar.-Apr. 1953.

Author applies the "homographic approximation" for transonic flow problems due to Germain [AMR **5**, Rev. 2885] to calculate a nozzle shape corresponding to a steadily increasing velocity along the axis and a wing profile with cusped leading and trailing edges. Author states that the approximation is very useful in the subsonic region but deteriorates rapidly in the supersonic region. In a preface to the paper, Legendre states that author's conclusions, as based on his particular applications, give too pessimistic an appraisal of the approximation. Maurice Holt, England

Turbulence, Boundary Layer, etc.

(See also Revs. 1017, 1154, 1158, 1178, 1205, 1248, 1279, 1293, 1327)

1191. Low, G. M., The compressible laminar boundary layer with heat transfer and small pressure gradient, *NACA TN* 3028, 68 pp., Oct. 1953.

The velocity and temperature distributions over an airfoil producing weak pressure gradient in the main stream are calculated by the compressible laminar boundary-layer theory. It is assumed that the main stream velocity, pressure, and temperature can be represented by polynomials. After the boundary-layer equations are transformed by Howarth's transformation [AMR **2**, Rev. 357], a perturbation procedure is carried out in a manner similar to Howarth's incompressible case [*Proc. roy. Soc. Lond.* (*A*) **164**, 547–579, 1938]. The resulting system of differential equations giving velocity and temperature are integrated numerically for the ratio of specific heats 1.40 and Prandtl number 0.72. With these results, the skin-friction and heat-transfer characteristics are studied under different pressure distributions.

Y. H. Kuo, USA

1192. Wick, R. S., The effect of boundary layer on sonic flow through an abrupt cross-sectional area change, *J. aero. Sci.* **20**, 10, 675–682, Oct. 1953.

Experimental results are obtained for flow through a two-dimensional channel consisting of a convergent section, a straight section, and an enlarged section connected in series. The flow attains sonic velocity just before expanding suddenly into the enlarged part of the channel.

The results, obtained by varying the straight and enlarged sections, confirm that the pressure in the corner of the expansion (base pressure) depends on the boundary-layer characteristics upstream of the expansion. In all cases the boundary layer is turbulent.

An empirical formula is derived from the experimental results which expresses the base pressure in terms of the expansion ratio and the dimensions of the straight section.

A. R. Mitchell, Scotland

1193. Bloom, M., Boundary layers with variable heat capacity on nonisothermal surfaces, *J. aero. Sci.* **20**, 10, 719–720, Oct. 1953.

1194. Krzywoblocki, M. Z., Possible particular solutions of the laminar boundary layer equations along a flat plate in hypersonic flow in continuum and in rarefied gases, *J. aero. Soc. India* **5**, 2, 23–35, May 1953.

Starting from simplified Burnett equations and the Beattie-Bridgeman equation of state, author develops a method of solving two-dimensional hypersonic boundary-layer equations for case of laminar flow. Method is a generalization of those employed by Crocco [AMR **3**, Rev. 547], Hantzsche and Wendt [Jahrbuch der deutschen Luftfahrtforschung, 1940], and others, the essential feature being that the partial-differential equations of motion are transformed to ordinary differential equations by introducing a new independent variable z replacing x and y (for example, after Prandtl's suggestion, by setting $z = x^{-1/2}y$). Application of method to the actual solution of hypersonic boundary-layer flows involves the use of either a digital computer or a differential analyzer and is not carried out by author. The paper is, in reviewer's opinion, of mathematical interest and may prove especially useful in treating hypersonic slip flows.

A. J. Eggers, Jr., USA

1195. Witting, H., Improvement of the H. Görtler difference method for the evaluation of the laminar boundary layer (in German), *ZAMP* **4**, 5, 376–397, 1953.

The method of differences developed by H. Görtler [*Ing. Arch.* **16**, 1948] and the method of K. Schröder [*Math. Nachr.* **4**, 1951] for the calculation of steady, laminar, plane, and incompressible boundary layers lose some accuracy because boundary conditions are satisfied on a line displaced from the original body surface. Present paper is aimed at a more exact treatment by assuming a polynomial approximation of the velocity distribution near the wall. This refinement leads to an increase in computational time which, however, it is claimed is more than offset by the increased accuracy of the results. The sensitivity of the method with respect to propagation of errors is generally reduced. Application of the proposed method has been made with success on several examples. S. Ostrach, USA

1196. Sandborn, V. A., Preliminary experimental investigation of low-speed turbulent boundary layers in adverse pressure gradients, *NACA TN* 3031, 37 pp., Oct. 1953.

As part of a study of turbulent-flow separation, measurements of velocity profiles and skin friction in subsonic turbulent boundary layers with adverse pressure gradients are presented. Purpose is to investigate validity of Maskell's semiempirical method of predicting boundary-layer parameters and of the Ludwieg-Tillmann formula for predicting local skin-friction coefficients. A 6-by 60-in. boundary-layer channel with porous suction on one wall was used together with pressure probes to measure velocity profiles, and a calibrated heat-transfer instrument to measure skin friction. Because position of separation was apparently time-dependent, smoke, total pressure measurements, and "china clay" evaporation method were unsuccessful in indicating a precise position. Comparison of the approximate form factor H in the region of separation with similar measurements of other investigators substantiated conclusion that this parameter alone is

a poor precise indicator of separation. Local skin-friction coefficient in an adverse pressure gradient decreased toward zero at separation region qualitatively, as predicted by Ludwieg-Tillmann. Maskell method and the Ludwieg-Tillmann formula are concluded to be useful for computations of the accuracy required in useful engineering practice.

Reviewer believes it unfortunate that no reference was made to the more careful experiments and analysis of Clauser ["Turbulent boundary layers in adverse pressure gradients," The Johns Hopkins University Contract no. AF 33(038)9862, June 1953]. In view of Clauser's difficulties in obtaining two-dimensional flow, evidence presented to show that flow was two-dimensional in 6- by 60-inch channel is questionable. Furthermore, it is believed that reasons given for choice of the calibration curve of heat-transfer skin-friction instrument are debatable, and agreement between measurements and predictions of local skin friction may be more in error than indicated. W. F. Davis, USA

1197. **Bauer, W. J., The development of the turbulent boundary layer on steep slopes,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 281, 23 pp., Sept. 1953.

Author presents data on velocity profiles, boundary-layer thickness, and friction coefficient for water flowing down slopes inclined from 20° to 60° with the horizontal. Data are given for smooth (glass) and rough (screen-covered) surfaces. The spillway-type flow investigated involves acceleration without pressure gradient and a free surface which eventually intersects the developing boundary layer. Local friction coefficients calculated from the momentum equation for this type of flow were plotted against Reynolds number based on local boundary-layer thickness for the smooth surface and against relative roughness for the screen-covered surface. These correlations agreed well with flat-plate skin-friction formulas derived from the logarithmic velocity profile.

Variation of boundary-layer thickness δ with distance along the slope x was almost linear and independent of slope angle and flow rate in the range investigated. A steeper rate of increase was obtained, however, for the rough surface than for the smooth surface. Reviewer notes that correlations of δ/x against Reynolds number (fig. 6) and relative roughness (fig. 7) appear questionable, since they depend strongly on choice of origin of x, which is fairly arbitrary. Small upstream movement of the effective origin makes δ/x almost independent of x. Use of these constant values of δ/x in computing the intersection of boundary layer with free surface can yield quite large differences between smooth and rough surfaces. One of the conclusions of the author, that roughness does not greatly affect the location of the intersection, appears, therefore, to be unwarranted on the basis of the data presented. W. E. Moeckel, USA

1198. **Klebanoff, P. S., and Diehl, Z. W., Some features of artificially thickened fully developed turbulent boundary layers with zero pressure gradient,** *NACA Rep.* 1110, 27 pp., 1952.

Supersedes article reviewed in AMR **5,** Rev. 1496.

1199. **Tetervin, N., Status of the theory of the turbulent boundary layer with pressure rise,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 853–858, 1952.

During the past 20 years the problem of calculating the behavior of the turbulent boundary layer in the presence of pressure gradients attracted the attention of a number of investigators without resulting in a satisfactory solution. Critical summaries of the more important papers are given. Each summary gives the major assumptions upon which each method is based and states whether, in the light of present knowledge, the assumptions appear to be valid or not. It seems that the investigations of turbulent boundary layers in the presence of pressure gradients have resulted in only two main findings, namely, that all the velocity profiles form essentially a single-parameter family, and that the form of the equation for the rate of change of the profile-shape parameter is obtainable from the Prandtl boundary-layer equation. It is concluded that a sound solution of the problem requires the ability to compute the shearing stresses in turbulent flows of the boundary-layer type.

From author's summary by M. Finston, USA

1200. **Korobkin, I., Apparent recovery factors on the leading edge of a flat plate in supersonic laminar flow,** *J. aero. Sci.* **20,** 8, 578–579, Aug. 1953.

Author suggests that experimental recovery factor for laminar boundary layer in supersonic flow over a flat plate is larger than theoretical prediction $Pr^{0.5}$ because heat is conducted through the plate. For small inclination of lower surface, a one-dimensional heat-conduction equation gives the equilibrium temperature in terms of Bessel functions. Solution assumes tip is insulated from rest of wedge. Although corrections to recovery factor from this interesting suggestion are in the right direction, reviewer feels that the theory suffers through omission of the physical effects of thermal contact between tip and rest of the wedge and downstream boundary layer and wedge. W. Griffith, USA

1201. **Dunn, D. W., and Lin, C. C., On the role of three-dimensional disturbances in the stability of supersonic boundary layers,** *J. aero. Sci.* **20,** 8, 577–578, Aug. 1953.

Calculation of the stability characteristics with three-dimensional disturbances are presented for a stream Mach number of 1.6 and a wall-to-stream temperature ratio of 1.073. For these conditions, the two-dimensional disturbances are completely stabilized, whereas the critical Reynolds number of the oblique disturbances is less than 2×10^6. Thus the authors conclude that, "by such cooling processes, one can materially delay the transition process but cannot achieve complete stabilization."

E. B. Klunker, USA

1202. **Kuethe, A. M., Review of transport processes in turbulent shear flows,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 85–101, 1953.

Aerodynamics of Flight; Wind Forces

(See also Revs. 1089, 1090, 1182, 1186, 1187, 1222, 1223, 1291, 1292)

1203. **Hunton, L. W., and James, H. A., Use of two-dimensional data in estimating loads on a 45° sweptback wing with slats and partial-span flaps,** *NACA TN* 3040, 40 pp., Nov. 1953.

A study has been made of the application of two-dimensional data and span-loading theory for estimating the local loading characteristics on a swept wing with flaps. Estimated results, including local pressure distributions, span loadings, and the nonlinear local lift characteristics, are compared with similar results measured at large scale on a 45° sweptback wing of aspect ratio 6 having a 0.4-span double-slotted flap both with and without a full-span slat.

Two-dimensional pressure distributions when corrected for sweep were found to agree closely with the wing pressures for most local sections either on or off the flap. This agreement continued to the higher lift coefficients and even improved near maximum lift where the flap-induced effects became minimized. The Weis-

inger 7 × 1 method was found to provide reasonably accurate span loadings for this swept-wing configuration, which had a relatively highly loaded type of flap. Two-dimensional lift data, together with span-loading theory, afforded quite accurate estimates of the local nonlinear lift characteristics, including maximum lift of sections outboard of the flap, but were inadequate for inboard sections of the wing where the three-dimensional boundary-layer control exercised a dominant effect.

From authors' summary by R. M. Crane, USA

1204. Mellenthin, J. A., The flow about a section of a finite-aspect-ratio NACA 0015 airfoil on a transonic bump, *NACA TN* 3036, 30 pp., Oct. 1953.

Pressure distributions on a semispan rectangular wing model having an NACA 0015 airfoil section and a moderate aspect ratio were measured at one spanwise station in tests made on a transonic bump in the Ames 16-ft high-speed wind tunnel. The free-stream Mach number range was from 0.4 to 1.06. The results showed that, at a fixed angle of attack, a region developed over the airfoil wherein the Mach number at each point remained essentially constant as the free-stream Mach number was increased above the critical. This region covered essentially the whole chord of the airfoil at free-stream Mach numbers near unity.

From author's summary by J. V. Becker, USA

1205. Heughan, D. M., An experimental study of a symmetrical aerofoil with a rear suction slot and a retractable flap, *J. roy. aero. Soc.* **57,** 514, 627–645, Oct. 1953.

The 10-in. chord, 25% thick, two-dimensional airfoil was tested at Reynolds numbers up to 8×10^5. The airfoil had a favorable pressure gradient over its entire surface. Experiments included pressure distributions over entire surface, smoke and tuft tests, and wake traverses for drag coefficients. Lift was obtained from measured pressure distributions, and a strain-gage balance was used to measure lift and pitching moment. Main purpose of investigation was to determine whether a circulation established with the aid of a flap would remain unchanged if flap were withdrawn without the appearance of a wake. When sufficient suction was applied to rear slot to remove all the boundary-layer air it was essential, for stable flow, for the trailing edge of flap to be beyond the enclosing streamline. During retraction of flap a large and violent three-dimensional instability occurred when trailing edge of flap moved from without to within enclosing streamline; the instability was associated with the occurrence of the stagnation point in the free fluid. The lift did not remain constant as flap was retracted but changed by a large amount. During unstable flow an increase in suction flow increased rather than decreased the wake-drag coefficient.

N. Tetervin, USA

1206. Martin, J. C., and Gerber, N., The second-order lifting pressure and damping in roll of sweptback rolling airfoils at supersonic speeds, *J. aero. Sci.* **20,** 10, 699–704, Oct. 1953.

Method is based on the Prandtl-Busemann method of iteration of equation of continuity, extended by Van Dyke [AMR **4,** Revs. 1653, 2575]. Time variation in equation is eliminated by ultilizing suitable coordinates. Airfoils considered are infinite swept wings with arbitrary symmetrical cross sections. Second-order effect on lifting pressure for unswept wings is found to be a function only of local slope of airfoil surface. Linearity of thickness effects on pressure is true for angle of attack, steady pitching, and other types of motions. Damping-in-roll (calculated from pressure distribution) varies directly as thickness of trailing edge. Given figure indicates considerable agreement between theory and experiment.

F. Keune, Sweden

1207. Hunton, L. W., Effects of finite span on the section characteristics of two 45° sweptback wings of aspect ratio 6, *NACA TN* 3008, 32 pp., Sept. 1953.

A study has been made of the finite-span effects on the local loading characteristics of two sweptback wings at low speed with a view toward providing some insight into the usefulness of two-dimensional section data and span-loading theory for determining the section characteristics of a swept wing. The two wings considered were identical in planform, having 45° of sweepback of the quarter-chord line, an aspect ratio of 6, and a taper ratio of 0.5, but differed in twist and in sections, the latter being the NACA 64A010 and NACA 64A810. The analysis is based on comparisons of local pressure distributions and local lift characteristics on the wings with comparable two-dimensional section data, all of which were available at large scale.

From author's summary

1208. Hemenover, A. D., The effects of camber on the variation with Mach number of the aerodynamic characteristics of a 10-percent-thick modified NACA four-digit-series airfoil section, *NACA TN* 2998, 34 pp., Sept. 1953.

The results of a wind-tunnel investigation to determine the effects of moderate amounts of camber on the aerodynamic characteristics of a 10-per cent-thick modified NACA four-digit-series airfoil section are presented for Mach numbers from 0.3 to 0.9. The corresponding Reynolds number variation was from approximately 1×10^6 to 2×10^6. The characteristics of airfoil sections cambered for design lift coefficients of 0.2 and 0.4 on an NACA $a = 0.8$ mean line are compared with those of the corresponding uncambered profile. The results indicate that the principal effects of increasing camber were an increase in maximum lift coefficient and increases in lift- and drag-divergence Mach numbers at moderate to large lift coefficients.

From author's summary

1209. Cocke, B. W., Jr., Fink, M. P., and Gottlieb, S. M., The aerodynamic characteristics of an aspect-ratio-20 wing having thick airfoil sections and employing boundary-layer control by suction, *NACA TN* 2980, 63 pp., Aug. 1953.

An investigation has been conducted to study the aerodynamic characteristics of an aspect-ratio-20 wing having thick airfoil sections and employing boundary-layer control by suction. Data from model tests in both the Langley full-scale tunnel and the Langley low-turbulence pressure tunnels are included. The results indicate the effects of varying suction flow rate, suction-slot configuration, wing-surface condition, flap deflection, and Mach number.

The results indicate that, through the use of boundary-layer control by suction, trailing-edge separation was controlled and lift-drag ratios as high as 30.8 were attained in the lift-coefficient range from 0.9 to 1.0 for the smooth-wing configuration. Up to a Mach number of 0.44, test results show compressibility effects to be only minor for the lift-coefficient range up to and including 1.0. With full-span trailing-edge flaps installed and maximum suction flow rates applied, maximum lift coefficients of 2.5 and 4.2 were obtained for flaps-neutral and flaps-deflected conditions, respectively.

From authors' summary

1210. Walker, K., Jr., The supersonic thickness drag of rectangular wings with linear spanwise taper in thickness, *Douglas Aircr. Co. Rep.* SM-14739, 22 pp., Mar. 1953.

The supersonic thickness drag of a rectangular wing with a linear taper in thickness from root to tip is studied. The airfoils considered are symmetric, specifically a double wedge, a modified double wedge, and a biconvex airfoil.

The correction to the results obtained with strip theory is developed using the source-sink method of linearized supersonic wing theory. The correction depends on the reduced aspect ratio $AR(M^2 - 1)^{1/2}$ and on the thickness taper ratio. In particular, it becomes larger as the reduced aspect ratio decreases.

A. Miele, USA

1211. **Küchemann, D., Concerning the flow on ring-shaped cowlings. Part XIII. The influence of a projecting hub,** *NACA TM* 1361, 19 pp., Oct. 1953.

Translation of *ZWB Untersuchungen und Mitteilungen* no. 3144.

1212. **Pearcey, H. H., and Rogers, E. W. E., The effect of compressibility on the performance of a Griffith aerofoil,** *Aero. Res. Counc. Lond. Rep. Mem.* 2511, 30 pp., Nov. 1946, published 1953.

Report of a 1946 experimental investigation on drag of 22% thick Griffith airfoil at zero incidence. Two subcritical (0.4, 0.6) and one supercritical (0.7) Mach number were investigated. Pressure distributions, shadowgraphs, and wake surveys were included for various amounts of suction using several slot configurations. For more efficient slot at subcritical speeds, estimated power absorbed by compressor is slightly less than that saved by drag reduction below valve measured for no suction. Data are incomplete at supercritical Mach number due to limitations of pump.

D. R. Chapman, USA

1213. **Hancock, G. J., Method for the determination of the pressure distribution over a finite thin wing at a steady low speed,** *Aero. Res. Counc. Lond. curr. Pap.* 128, 11 pp., Sept. 1952, published 1953.

A simplified lifting-surface theory technique, developed for determining the twist and camber required of a lifting surface to support a given pressure distribution in incompressible flow, is applied to the inverse problem. This approach to finding wing-pressure distributions is not new and author's only claim to originality lies in the simplicity of his method and the resulting reduction in time and effort required for a solution. Comparison of his results for a thin uncambered 45° sweptback wing with those of a more precise method shows appreciable discrepancies. Recommendations on how to obtain better results are included, however.

A. L. Jones, USA

1214. **Campbell, J. P., and McKinney, Jr., M. O., A preliminary study of the problem of designing high-speed airplanes with satisfactory inherent damping of the dutch roll oscillation,** *NACA TN* 3035, 40 pp., Oct. 1953.

Paper presents values for period and damping time of Dutch-roll oscillation for typical fighter configurations designed for high subsonic speeds. It is concluded that undesirable Dutch roll can be reduced by use of maximum aspect ratio, minimum sweep, low radius of gyration, and large nose-up inclination of the principal axis of inertia.

L. H. Schindel, USA

1215. **Phillips, W. H., Graphical solution of some automatic-control problems involving saturation effects with application to yaw dampers for aircraft,** *NACA TN* 3034, 41 pp., Oct. 1953.

Using the phase plane, a graphical method is given for determining motion of freely oscillating system of one degree of freedom stabilized by a controlling device operating beyond the linear range. In particular, yawing motion of an airplane controlled by the rudder is considered. Relations required for construction of graphs in which motion is represented by true logarithmic spiral are derived.

In order to illustrate different features of method, five examples are worked out in detail, from which reader gets clear insight into procedure. Results show saturation effects of limitation of rudder deflection, rudder rate of movement, or both on motion of system.

J. Buhrman, Holland

1216. **Söhngen, H., Aerodynamic forces in vibrating ring of blades with small gap chord ratio** (in German), *ZAMP* **4,** 4, 267–297, 1953.

For an investigation on the vibration behavior of a ring of blades of an axial compressor, knowledge of the aerodynamic forces on the individual blades is required. Since, at small gap-chord-ratio and possibly at high aerodynamic loading of the blades, the aerodynamic interference between the blades is not negligible, a method including the interference is given for evaluating the aerodynamic forces acting on an arbitrarily vibrating ring of blades. This method is valid for thin and slightly cambered blades, arranged with small gap-chord ratio, in nonviscous incompressible medium. (Reviewer wonders to what extent the boundary layer in a viscous fluid is able to adjust the circulation around a blade to fluctuating conditions in the upstream or, generally, in the flow field outside the boundary layer.)

From author's summary by E. R. G. Eckert, USA

1217. **Eggleston, J. M., A method of deriving frequency-response data from motion of the center of gravity from data measured on an aircraft at locations other than the center of gravity,** *NACA TN* 3021, 25 pp., Oct. 1953.

The current popularity of numerous methods for flight-testing models and full-scale aircraft has brought about many new developments in the measurement and reduction of flight-test data [See *NACA TN* 2262, 2340, 2347, 2977, 2997, and *NACA Rep.* 984, 1070.]

This report is concerned with the problem of obtaining angle-of-attack and normal-acceleration response data for the center of gravity when these quantities must be measured by instruments at some other location. A mathematical technique, based on the determination of transfer functions for the aerodynamic quantities involved, is provided for the derivation of either the time-response or frequency-response data at the center of gravity. Technique is applicable whether pitching velocity has been measured or not.

A. L. Jones, USA

1218. **von Doenhoff, A. E., and Jones, G. W., Jr., An analysis of the power-off landing maneuver in terms of the capabilities of the pilot and the aerodynamic characteristics of the airplane,** *NACA TN* 2967, 42 pp., Aug. 1953.

Paper presents analysis of power-off landing maneuver in which an attempt is made to consider pilot capabilities as well as airplane aerodynamics. It assumes pilot's distance judgment has a factor of error E_h and a time delay t_r between decision to correct airplane attitude and completion of such correction. Calculations are made including these parameters to modify the optimum landing paths, derived solely from aerodynamic considerations, so as to give inherent safety margins. Determination of minimum safe glide speed and definition of a region in which the pilot should fly for a safe landing in minimum distance are described. Several calculations based on assumed values of E_h and t_r are presented; results show desirability of research to determine accurate values of E_h and t_r.

From authors' summary by A. F. W. Langford, Australia

1219. Peyer, A., Aerial combat at high altitude (in German), *Flugwehr u. Technik* **15**, 5, 103–106, May 1953.

Based on logical estimates of lift, wing loading, and drag, the problem of attacking high subsonic bombers with manned interceptors is studied for various altitudes. Conclusions are that tail armament in the bomber is sufficient for defense against interceptors for high altitudes. To compete at all with missiles, interceptors must have supersonic capabilities and ability to fire at large angles relative to flight direction. E. T. Welmers, USA

1220. Coleman, T. L., and Schumacher, W. J., An analysis of normal-acceleration and airspeed data from a four-engine type of transport airplane in commercial operation on an eastern United States route from November 1947 to February 1950, *NACA TN* 2965, 27 pp., Aug. 1953.

1221. Hacker, P. T., Brun, R. J., and Boyd, B., Impingement of droplets in 90° elbows with potential flow, *NACA TN* 2999, 58 pp., Sept. 1953.

In connection with problems of ice prevention on aircraft, paths of water droplets in two-dimensional elbows are studied. The differential equations of the droplet motion, taken from *NACA TN* 2905, 1953, involve the velocity field of the air stream. By selecting as walls of each elbow two streamlines of the flow field produced by a complex potential function, the velocity field is known and the equations can be integrated. Pertinent droplet impingement data derived from the trajectories are presented.

L. Landweber, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 1162)

1222. Sisto, F., Stall-flutter in cascades, *J. aero. Sci.* **20**, 9, 598–604, Sept. 1953.

A theoretical analysis of the subject phenomenon is outlined, using methods of nonlinear mechanics with simplifying assumptions regarding the aerodynamic forces near the stall. The results are shown to agree qualitatively with experimental data. Desirable extensions of the theory are pointed out.

B. Smilg, USA

1223. Chopin, S., Determination of new modes and frequencies of vibration of an aircraft due to change of mass distribution (in French), *Rech. aéro.* no. 34, 29–31, July-Aug. 1953.

Author considers the effect of mass distribution on the modes and frequencies of a wing considered as a beam, (1) using an exact method and (2) replacing the beam by a number of discrete masses. It is shown that, to obtain accurate estimates of the effect of a change in the mass distribution, a large number of degrees of freedom must be considered—about double the number usually required for a flutter calculation. The author recommends ground resonance tests as a more practicable estimate of these effects. A. W. Babister, Scotland

1224. Chopin, S., Validity of calculated correction of modes of airplane following altered mass distribution (in French), *Rech. aéro.* no. 34, p. 32, July-Aug. 1953.

Author considers the effect of change of aileron balance weight on the modes and frequencies of vibration. The general conclusions are the same as in preceding review, and ground resonance tests are recommended. A. W. Babister, Scotland

1225. Forshaw, J. R., and Mountford, F. T., The determination of the natural frequencies of a full-scale airframe-engine system by the admittance method, *Aero. Res. Counc.. Lond. Rep. Mem.* 2667, 24 pp., July 1948, published 1953.

The development of the method of the measurement of admittances and the solution of the frequency equation for a complex full-scale airframe-engine system is given, dividing the dynamical system at the attachment of the engine to the airframe, and using a force system of equal and opposite bending moments and shearing forces.

The values of the resonance frequencies obtained from the graphical solution of the frequency equation and from the resonance tests are compared and found to be in good agreement. The method is applicable to the matching of an engine to an airframe by adjusting the flexibility of the mounting units.

From authors' summary by R. E. Heninger, USA

1226. Jones, W. P., Wing-fuselage flutter of large aeroplanes, *Aero. Res. Counc. Lond. Rep. Mem.* 2656, 46 pp., Nov. 1947, published 1953.

Part I contains the development of a dynamical matrix equation for a symmetrically fluttering aircraft. The degrees of freedom considered include pitch and translation of the aircraft as a whole, as well as wing bending and torsion, and fuselage vertical bending. The wing and fuselage degrees of freedom are expressed in terms of the motions of certain reference stations, but inertial and aerodynamic effects at additional intermediate stations are introduced by means of interpolating functions that are derived rationally from elastic considerations. Air loads on the tail (assumed rigid) as well as on the wing are calculated on the basis of classical (British) aerodynamic derivatives that are independent of frequency; author states, however, that frequency-dependent derivatives may be used instead. The theoretical development leans heavily on matrixes and is not easy reading.

Part II contains an application of the theory to a particular large transport airplane; twelve degrees of freedom are considered. Calculated natural (zero air speed) frequencies agree fairly well with results of scaled model tests; flutter calculations are carried far enough to show that flutter would not occur below the maximum design flight speed. B. Budiansky, USA

1227. Miles, J. W., An approach to the buffeting of aircraft structures by jets, *Douglas Aircr. Co. Rep.* SM-14795, 40 pp., June 1953.

The model used here is a single-degree-of-freedom (lightly damped) oscillator loaded at one point. The phenomena of essentially resonant and essentially static responses are exhibited and attention is directed toward the former. The random force acting is assumed to be Gaussian in time. The statistical relationships required in the analysis are taken from the work of Rice [*Bell System tech. J.* **23**, 282–332, 1944; **24**, 46–156, 1945; also Bell Telephone System Monograph B-1589]. A typical exponential curve is assumed to relate the number of stress reversals to the failure stress, and both Miner's rule [*J. appl. Mech.* **12**, 159–164, 1945] of linear accumulation of damage and Shanley's [Rand Corp. Rep. no. P-350, Santa Monica, Calif., 1952] of quadratic accumulation are proposed. Both lead to equivalent stresses proportional to the root-mean-square stress.

This theory is applied to the buffeting of a panel by a turbulent jet. Lighthill's theory [AMR **6**, Rev. 654] of noise generation in a jet is drawn upon for the root-mean-square pressure. Assuming that the characteristic frequency of the jet varies directly as its velocity and inversely as its diameter and that its power spectral density has a certain form, the equivalent stress is calculated.

The result involves two undetermined constants. It shows how the stress is affected by adding stiffness (for example) to the panel, and shows also the corresponding effect on the probable time for fatigue failure. W. R. Sears, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1169, 1188, 1216, 1267, 1285, 1286, 1297)

1228. **Hadekel, R., Displacement pumps and motors,** London, Sir Isaac Pitman & Sons, Ltd., 1951, vii + 170 pp. 25s.

The text is written for the specific purpose of presenting a broad, if not detailed, discussion of the various types of displacement pumps and motors currently in industrial use. As indicated in the preface, useful engineering information on the subject is seriously lacking in the literature, and the author is attempting to fill this gap.

Emphasis is on application rather than detailed design considerations. Piston, gear, and vane machines, as well as some other types, are well described (with many good drawings), evaluated, and compared. Construction problems, volumetric and mechanical efficiency, leakage, sealing, installation, and operation, as well as other problems, are discussed.

The book is of a qualitative rather than quantitative nature. Notably lacking are typical quantitative performance characteristics under varying load conditions. J. F. Manildi, USA

1229. **Sliosberg, P., Instability criteria for operation of centrifugal pumps** (in French), *Houille blanche* **8,** 4, 521–525, Aug.-Sept. 1953.

Author examines in detail stability of operation of a synchronous-drive centrifugal pump with an air vessel on delivery side. Relevant equations are linearized by considering only small variations in neighborhood of normal operating point. Nondimensional form, e.g. $(Q) = \Delta Q/Q_0$, is chosen for the variables. Elimination leads to third-order linear differential equation in (Q). The method of Hurwitz is then applied, leading to three stability criteria expressed in terms of four parameters m, n, α, β. The first two parameters are slopes of pump and pipe-line characteristics at normal operating point. Others are defined in terms of dimensions of particular installation.

Reviewer considers the analysis is sound but not simplified by partial use of nondimensional methods. Only one of four parameters, α, is nondimensional, while β has the dimensions of m^2, i.e., T^2/L^4.

Two misprints were noted, in equations (2) and (5) where, in each case, sign of last term should be +, not −.

Meaning and implication of parameters α and β are not fully discussed, and author omits to note that if m is negative, which is usually the case, all three stability criteria are satisfied. Numerical example given to show that a pump may be stable on test bed but unstable when installed is for positive m. Example appears to contain implication that air dissolved in water is equivalent in effect to an air vessel. If this is intended, some confirmation should be given. A. Burn, Australia

1230. **Maggiolo Campos, O. J., Influence of viscosity on the characteristics of centrifugal pumps** (in Spanish), *Fac. Ing. Montevideo, Pub. Inst. Mat. Estadis.* **4,** 4, Publication no. 9, 32 pp., 1952.

Based on experiments with his two small pumps and published tests of a few other larger ones, author extends Tetlow's method, which compares points of the specific speed at the maximum efficiency for liquids of different viscosity, to all points of the characteristic curve, with the efficiency ratio constant at corresponding points of same specific speed, even though this is more often contradicted than verified by tests. With this assumption and a one-dimensional approach comparing viscous performance with one with infinite number of vanes and no viscosity, author develops a method of constructing complete viscous characteristics from one given viscous point and a complete characteristics with liquid of different viscosity, say water; but he warns that the method should be used in a limited range.

A. Hollander, USA

1231. **Clark, P. M., Mechanical pumps for high-temperature liquid metal,** *Mech. Engng., N. Y.* **75,** 8, 615–618, Aug. 1953.

See AMR 6, Rev. 2895.

1232. **Stuart, M. C., and Jackson, T. E., The analysis and evaluation of compressor performance,** ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-53, 8 pp.

Data from a series of tests on a cooled and uncooled multistage centrifugal compressor are given. By using these data a comprehensive analysis of the energy transformation in both cooled and uncooled compressors has been made in an illustrative form; the first- and second-law energy analyses have been made for some idealized reversible processes between the same pressure range, such as adiabatic reversible compression, polytropic reversible compression, adiabatic reversible air engine working over the temperature of the surroundings, isothermal reversible compression, and adiabatic reversible air engine working under the surrounding temperature. And, as a primary objective, a series of performance coefficients, or figures of merit, have been defined and computed by using the results of these idealized processes.

From authors' summary

1233. **Downs, B., The "intrinsic efficiency" of a flow type air compressor,** *Engineer, Lond.* **196,** 5087, 101–102, July 1953.

A distinction exists between the application of the term isentropic efficiency to flow-type air compressors and air turbines, respectively. By considering the energy of the air ideally available for conversion into mechanical form, the concept of "intrinsic efficiency" of the compressor is established and is then compared with the isentropic and polytropic efficiencies. Illustrations of the processes are made on the T-ϕ diagram, and while air is assumed to have constant specific heat, the theory remains valid if variation in the specific heats of air is taken into account. Calculations, however, are modified and are most easily effected by the use of air tables. From author's summary

1234. **Stephenson, J. M., The propulsive efficiency and best division of power in an augmented jet engine,** *J. aero. Sci.* **20,** 8, 576–577, Aug. 1953.

Method previously used by I. H. Driggs [*Aviation Week,* 29–32, Nov. 15, 1948] to determine best power division between propeller and jet in turboprops is modified and extended to cover turbofans. Efficiencies of conversion of energy input to axial kinetic energy increment in jet nozzles and propellers or fans are assumed to be constant. Use of such conversion efficiencies involves consideration of by-pass ratio (ratio between mass flows through propeller or fan and gas generator) in analysis of augmentation effect. In particular, optimum power division depends on by-pass ratio. Thus, author's equation for best power division applies to turbofans as well as to turboprops and reduces substantially to Driggs' equation when by-pass ratio is very large, as in turboprops. J. V. Foa, USA

1235. Price, E. W., Theory of steady flow with mass addition applied to solid propellant rocket motors, *J. Amer. Rocket Soc.* **23,** 4, 237–241, July-Aug. 1953.

Calculations have been carried out to determine the rate of evaporation of a liquid droplet surrounded by hot gases. The present study represents an extension of earlier work by Penner on evaporation rates for isothermal droplets. In particular, allowance was made for temperature gradients within the droplet by considering a droplet composed of an isothermal core and an isothermal shell. The results obtained in the present investigation were found to be in satisfactory agreement with the known data for evaporation of isothermal droplets, thus justifying calculations for isothermal droplets as a reasonable first approximation.

From author's summary by W. W. Berning, USA

1236. Sänger, E., Air admixture to exhaust jets, *NACA TM* 1357, 35 pp., July 1953.

See AMR **4,** Rev. 3362.

1237. Sänger, E., Contribution to the theory of photon rockets (in German), *Ing.-Arch.* **21,** 3, 213–226, 1953.

Paper is an analytical study comparing different methods of rocket propulsion. In particular, little known propulsion techniques are discussed and compared with one another. Author proposes a so-called photon rocket in which particle reactions are used and the photons are discharged after having been suitably guided by appropriate reflectors. It is shown that the specific fuel consumption of such vehicles would be substantially lower in comparison with other types. Paper is comprehensive and computational results are included. A. B. Cambel, USA

1238. Salmon, M., The supersonic stato-reactor at moderate Mach numbers (in French), *Publ. sci. tech. Min. Air, Paris* no. 274, 103 pp., 1952.

Author considers a ramjet with a conical diffuser, a cylindrical combustion chamber, and a converging conical nozzle. The operation of the ramjet depends on the Mach number M_0, the static pressure p_0, and the temperature T_0 of the incoming flow and on the fuel mass flow g. Depending upon the values of M_0, p_0, T_0, and g, one can have the following operations: (1) Critical operation where the entrance shock wave is attached exactly to the entrance section; (2) supercritical operation where the shock wave is located downstream of the entrance section; (3) subcritical operation, where the shock wave is detached. With constant values of M_0, p_0, T_0, and g, these different operations can be obtained by changing the exit section of the nozzle; when starting from the critical operation, the supercritical operation can be obtained by increasing the exit section area, while the subcritical operation is realized by decreasing this area. Using this idea, the thrust, which is easily found for the critical operation, is also calculated for the supercritical operation. Further, a perturbation calculation is used to derive an expression for the thrust for subcritical operations which are close to the critical operation. Author uses the fuel mass flow per unit static pressure of the incoming flow and per unit entrance section area as a fundamental parameter p instead of the generally used, nondimensional mixture ratio. The performance of a ramjet for different operation conditions is studied and the design of a ramjet is discussed in some detail with the assumption that the efficiency of the diffuser, the efficiency of combustion, and the loss due to the flame holders are known. A number of diagrams are presented which are of great value for design purposes. H. G. Loos, USA

1239. Janaki Ram, G., and Acharya, Y. V. G., Circulation distributions on and induced efficiencies of propellers with three, four and infinite number of blades, *J. aero. Soc. India* **5,** 3, 62–66, Aug. 1953.

Using Goldstein's method for finding the circulation distribution on finite number of blades, extended by Lock and Yeatman for three- and four-bladed propellers, authors calculate the induced efficiencies for each case. A. Petroff, USA

1240. Busemann, A., Theory of the propeller in compressible flow, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 267–286, 1953.

The change in type of flow at sonic speed is replaced, due to the screwing motion of the blades, by a transonic mixture for all subsonic forward speeds of the propeller. Two types of losses enter the energy balance: the energy for the creation of the vortex field behind the propeller, and the energy carried by outgoing sound waves wherever the phases of the steady flow field attached to the screwing motion of the propeller travel with supersonic speed. The compressibility makes the propeller not susceptible to certain modes of load distribution. R. C. Binder, USA

1241. Costilow, Eleanor L., Application of a characteristic blade-to-blade solution to flow in a supersonic rotor with varying stream-filament thickness, *NACA TN* 2992, 36 pp., Aug. 1953.

Paper continues the work of Wu and Costilow [AMR **5,** Rev. 1132] by applying their method to the tip stream filament of a constant-tip-diameter supersonic impeller. The calculation procedure is described in detail. It was found that in the example used there was an appreciable difference between the flow properties obtained by this method and those calculated from the ordinary two-dimensional characteristic equations.

N. H. Johannesen, England

Flow and Flight Test Techniques

(See also Rev. 1181)

1242. Pearce, C. A. R., An electromagnetic torquemeter for use in viscometry, *J. sci. Instrum.* **30,** 7, 232–236, July 1953.

An instrument is described which measures the torque exerted on the cup of a conicylindrical viscometer by balancing it against the action of a coil carrying an electric current in a magnetic field. A servo system incorporating a novel form of mechanical-electrical transducer automatically adjusts the coil current. The measurement depends only on the electromagnetic constant of the instrument which has been determined with an accuracy better than $\pm 0.6\%$ and should remain unaltered indefinitely. The measured torque is this constant multiplied by the torque coil current.

In addition to measuring the torque, the instrument can be arranged to control the viscometer speed and therefore the rate of shear, so as to maintain the shearing stress in the oil under examination of a predetermined value. Design details and the results obtained with castor oil and with an oil having non-Newtonian properties are included. From author's summary

1243. Roth, W., and Rich, S. R., A new method for continuous viscosity measurement. General theory of the Ultra-Viscoson, *J. appl. Phys.* **24,** 7, 940–950, July 1953.

The viscometer operates by measuring the attenuation of an elastic shear wave which is magnetostrictively induced in the metal strip of the probe as a function of time. Its standard operating frequency is about 28 kcps, which results in a peak

amplitude of less than $^1/_2$ micron. When the probe is immersed in a liquid the strip acts as a source of transverse vibrations. A discussion is given relating the propagation and attenuation of the transverse waves to the different properties of viscoelastic materials. For Newtonian liquids, this leads to an equation where the viscosity × density is directly proportional to the damping coefficient. For non-Newtonian materials, the relation is somewhat more complicated. The probe is connected to an analog computer whose purpose is to generate the pulse that sets the probe into vibration and also to produce an electrical output which is proportional to the damping coefficient of the transverse waves. The instrument thus is directly reading in units of viscosity × density for Newtonian liquids. For non-Newtonian materials, the reading is a function of all flow properties combined, so that it is difficult to relate it either to visosity or to rigidity alone or to other more complex flow behaviors. Experimental data are presented. The viscometer seems especially well suited for purposes of plant control and automation, since the computer produces an electrical output and because of the small size of the measuring probe. Ruth N. Weltmann, USA

1244. **Gunaji, V. N., and Villemonte, J. R., Effect of pressure and temperature on the viscosity of petroleum oils,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 719–740, 1953.

Tests at pressures from zero to 2000 psig and temperatures from 55 F to 140 F were run on petroleum oils of viscosity 0.000041 to 0.00125 lb-sec per sq ft at 100 F. Viscosity measurements were made by means of a falling sphere viscometer developed especially for this work. Authors conclude that (a) the viscosity of oils within the above-mentioned range, subjected to temperature and pressure, may be predicted; (b) the pressure coefficient of viscosity is a function of temperature which can be expressed by a rather simple equation; (c) the viscosity of any liquid can be determined accurately by use of Stokes' law for N_R below 65 if suitable corrections are applied to the viscometer.

J. S. Marcus, USA

1245. **Swindells, A., An instrument for measuring speed fluctuations and a method of calibrating such instruments,** *J. sci. Instrum.* **30,** 10, 364–365, Oct. 1953.

An a-c tachogenerator followed by amplifier and filter equipment has been used to measure fluctuations in low rotational or linear speeds. The sensitivity is such that speed fluctuations in the frequency range of 10–60 cps and amplitude 0:1 rps can be measured directly, or 0:03 rps with an auxiliary amplifier. The load imposed on the measured system is low. A new method has been devised for the calibration of the instrument. A differential gear box summates a steady speed and a sinusoidal oscillation, and the instrument is calibrated on the known output velocities of the differential. From author's summary

1246. **Gould, R. W. F., Differential inductance telemeter equipment for force and moment measurements,** *J. roy. aero. Soc.* **57,** 510, 416–419, June 1953.

1247. **Cook, D. B., and Danby, C. J., A simple diaphragm micromanometer,** *J. sci. Instrum.* **30,** 7, 238–240, July 1953.

A diaphragm vacuum gage covering the pressure range 1 to 100μ with an accuracy of better than 0.5μ is described. Movement of the diaphragm is followed by measurement of capacity change. The electronic circuit involves only a single valve. The gage is suitable for measurement of mass-spectrometer sample inlet pressures. From authors' summary

1248. **Ross, A. O., Determination of boundary-layer transition Reynolds numbers by surface-temperature measurement of a 10° cone in various NACA supersonic wind tunnels,** *NACA TN* 3020, 26 pp., Oct. 1953.

For five tunnels at the NACA Ames Laboratory and four at the NACA Lewis Laboratory of various types and in sizes from 1 ft square to 8 × 6 ft, the transition Reynolds number variation with stream Reynolds number and with Mach number was most inconsistent. Various causes for the inconsistencies are suggested and the effect of one (tunnel disturbance caused by a 0.0025-in. tape) is shown in the review. J. M. Robertson, USA

1249. **Wattendorf, F. L., Noyes, J., and Ponomareff, A. I., High-altitude and speed propulsion wind tunnel,** *Mech. Engng., N.Y.* **75,** 10, 789–793, Oct. 1953.

1250. **Squire, H. B., and Winter, K. G., The Royal Aircraft Establishment 4 ft × 3 ft experimental low turbulence wind tunnel, Part I,** *Aero. Res. Counc. Lond. Rep. Mem.* 2690, 28 pp., Feb. 1948, published 1953.

A 4 × 3-ft closed-return, closed-throat, low-turbulence-type wind tunnel is fully described. Small angle diffusion followed by rapid expansion through screens ahead of the working section gives very uniform velocity distribution throughout. A novel bypass speed control is employed. Large contraction ratio (31.2:1) should give low test-section turbulence, but turbulent measurements were not made. H. J. Allen, USA

1251. **Scherberg, M. G., and Foote, J. R., Wind tunnel resonance investigation,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 479–494, 1953.

Paper discusses problem of propagation of wind-tunnel pressure pulsations. The wave equation is utilized to predict circuit resonance frequencies, and circuit times are estimated. Reviewer notes that, essentially, a shock tube was utilized to generate the pressure pulses. A nonstationary shock wave is produced. This aspect of the problem and its effects on the analysis and the experimental results are not discussed.

Authors point out that useful systematic research data are not available for tunnel resonance. In practice, it is resolved probably by avoiding wind-tunnel tests at speeds which give rise to resonant frequencies—a procedure that does not contribute to the solution of this problem. I. I. Glass, Canada

1252. **Clarke, D. A., High-speed tunnel tests of a 5 per cent chord dive-recovery flap on a NACA 0015 aerofoil,** *Aero. Res. Counc. Lond. Rep. Mem.* 2689, 19 pp., June 1948, published 1953.

Pressure-plotting tests were made in the RAE high-speed tunnel on a parallel wooden NACA 0015 wing with dive-recovery flap. The Mach number was varied between 0.30 and 0.80 and the Reynolds number was kept constant at 1.4×10^6. All combinations of the following were tested: flap position 0.2c, 0.3c, 0.4c; flap angle 20 deg, 40 deg, incidence 0 deg, 4 deg. The flap-chord/wing-chord ratio was 0.05.

The report presents a general picture of the action of a dive-recovery flap on a wing. The data are, however, too limited to permit the formulation of general design recommendations.

From author's summary

1253. **Wilkie, M. J., and King, R. F., A wave-height analyzer,** *J. sci. Instrum.* **30,** 9, 311–314, Sept. 1953.

This instrument uses a 34-element probe, relays, stepping selector switch, and 32 counters to determine distribution of wave heights in an irregular train of surface waves, of period 1 sec or

greater. Wave height is difference between a minimum and succeeding maximum of elevation. Use of this quantity is conventional [*Trans. Amer. geophys. Un.* **27**, p. 823, 1946], but reviewer considers it is not the most fundamental method of analysis [see, e.g., AMR **6**, Rev. 2662]. P. Rudnick, USA

1254. Campbell, I. J., Wave motion in an annular tank, *Phil. Mag.* (7) **44**, 355, 845–853, Aug. 1953.

An annular towing tank is described in which a model is moved through the water in a circular path. At certain critical towing speeds, characteristic waves develop on the water surface. The number of diametric and circumferential nodes in the wave motion depends on towing speed. Author presents a theoretical analysis of wave formation round the inner wall of an annular tank when a pressure point circulates around outer wall. A solution for the hydrodynamic wave equation is found in terms of a Fourier series. Author shows that, for his case, waves of fairly large amplitude are likely to appear only when the model is towed around with a frequency approximately equal to the frequency of the (s, n) mode divided by s, where s is the number of diametrical nodes and n the number of circumferential nodes. Experimental observations of waves of mode (s, n) between $(1, 0)$ and $(5, 3)$ gave critical towing speeds in good agreement with those calculated from theory. D. W. Pritchard, USA

1255. Dmitriev, A. A., and Bonchkovskaya, T. V., Polarized-light method applied in the observation of wave movements in the vicinity of a vertical, hard wall (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **90**, 3, 347–349, May 1953.

Waves in water (11 cm deep in a tank 200 cm by 15 cm, with a damper) are generated and their reflection from a vertical end-wall is studied by an undefined "polarized-light method." Apparently, spots on a film record of the motion are assumed to represent water particles. Resulting trajectories show deviations from nonlinear theory and are vaguely ascribed to "non-ideal circulation near the wall" and to spurious wave reflections from the wave generator. M. V. Morkovin, USA

1256. Falkemo, C., On the possibilities of estimating the towing resistance of ships by tests with small models, I, *Trans. roy. Inst. Technol. Stockholm* no. 64, 51 pp., 1953.

Investigations at the Ship Testing Laboratory of the Royal Institute of Technology are reported. With 1-m and 2-m models, experiments were made at low values of Reynolds number (up to 2.5 million). The shape and extent of laminar flow being important here, they have been investigated by means of the soluble film technique. Comparison was made with earlier tests on approximate 6-m models.

Tangential forces in the longitudinal direction of the ship are termed skin or frictional resistance. Projections of normal forces make up the pressure resistance. The total resistance depends on form, velocity, or Reynolds (Re) number and Froude's number, including acceleration of gravity, initial turbulence, roughness or surface finish of the model, temperature, density and surface tension, or Weber's number and cavitation number.

The coefficient of total resistance can be approximated by three functions: The frictional coefficient (dependent on Re for the model or ship, Re at the transition point, form, and roughness); the coefficient of wave resistance (form, Froude, and Re numbers); and by the coefficient of complementary pressure resistance (form, Froude, Re). Resolution into components is supposed to be possible. It is assumed that cavitation does not influence resistance of models in an open tank, that initial turbulence influences transition Re only, that friction is independent of wave-making, and that surface tension is negligible. For transforming towing-test results to full size, further approximation gives the frictional coefficient (dependent on Re and roughness) and a combined wave and complementary pressure, the "coefficient of residuary resistance" (dependent on form and Froude's number, and including also an approximation for frictional resistance as dependent on form of hull).

This approximation is acceptable for Re over 3 million, with corrections estimated for resistance of air, steering, appendages, etc., and assuming (a) that laminar boundary-layer friction is slight, (b) form can be neglected, and (c) boundary-layer effect on pressure distribution can be disregarded. For smaller Re numbers, assumption (c) may be too rough, and for Re less than 2 million, assumption (a) is no longer admissible because of the prevailing laminar flow.

For the coefficient of skin resistance, the boundary determinations between laminar and turbulent regions are required. The actual, gradual transition region is to be replaced by a boundary line. This depends on the initial turbulence, pressure distribution, and surface finish. The calculations for simple geometrical solids cannot be made for ship models. Experimental determination can be made by a sublimation technique using a thin film of sparingly soluble solid which diffuses at rates different for laminar and for turbulent flow. Frictional resistance cannot be determined directly from boundary-layer equations, and an assumption is made that hull friction equals that for a rectangular plane surface of same water-line length and of the same area as the wetted surface of the ship (at rest), when the plane is moved at the same velocity. Actual friction of hull and that of the plane surface are in ratio called "the form influence ratio."

Due to lack of agreement of approximate formulas, Schönherr's empirical formula has been generally recommended as well as previously adopted in the United States. It gives a relation between skin resistance and Re. The influence of form on friction is approximately independent of Re.

For the coefficient of complementary pressure resistance, determination is required of the difference of the longitudinal components of pressure in actual flow and in potential flow. If the flow does not separate, the wake may be regarded as a continuous extension of the turbulent boundary layer, and the pressure resistance can be approximated in theoretical methods. At very low values of Re, towing tests are probably not possible for complementary pressure determination. The investigation, though not yet sufficient, indicates only a slight variation of the complementary resistance with Re.

Experiments for the coefficient of wave resistance indicate that it is independent of the scale. Comparison tests can readily be made between the 1-m and the 2-m models.

The soluble film method of testing uses a substance which is initially colorless but forms a white solid film when sprayed onto the model. The model is previously painted black. The film dissolves most rapidly in the turbulent boundary layer. Therefore, laminar regions will be represented by areas of lighter color shade. From tests, it is apparent that eddies starting from the bow wave and forward end of keel, bound the laminar areas at the forebody. From the tests, it seems possible to make correction for the laminar regions determined by means of the soluble film. Mean curves are obtained for the friction in turbulent flow of a plane surface, corresponding to that of the models, and the curves are independent of the model forms.

In principle, it ought to be possible to expand to full size the model data by a method involving separation into frictional resistance and residual resistance, with correction for variation in friction with form of model. Correction for laminar surfaces is considerable, compared with the coefficient of residual resistance. As laminar areas on the 2-m models are relatively smaller than on

the 1-m models, their boundaries are sharper, due to more intense eddies, and the larger model size is the more preferable.

E. Smith, USA

Thermodynamics

(See also Revs. 1039, 1133, 1231, 1234, 1236, 1238, 1268, 1288, 1294, 1309)

1257. **Jacobs, P., Pseudoadiabatic changes of open gaseous systems** (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **39,** 1, 94–104, 1953.

Author names the change of states in an open system, pseudoadiabatic when the heat flow is zero. The laws of such changes are investigated and, especially, the adiabatic exponent, corresponding to the specific heat ratio in a closed system of ideal gas, is derived for an open system of ideal gas mixture with condensable components.

Reviewer considers author's implicit definition of heat flow in open system of mixture, with due consideration of the partial enthalpy of each component, as most appropriate in contrast to the definition sometimes made using specific enthalpy of mixture [e.g., Tolhoek and De Groot, AMR 6, Rev. 2033].

The calculation of flow rate in charging a gas reservoir by using adiabatic law instead of isothermal is instructive but not new.

L. S. Dzung, Switzerland

1258. **Popoff, K., Thermodynamics of irreversible processes where the temperature and pressure remain constant** (in French), *C. R. Acad. Sci. Paris* **237,** 14, 698–700, Oct. 1953.

A system at constant pressure and temperature is allowed to exchange heat with its surroundings. It is shown that the phenomenological relations are first integrals of a Newtonian set of equations. If the deviation of the negative of the ratio of Gibbs' free energy to temperature from its equilibrium value is expressed as a quadratic function of the variables other than T and p, then the Onsager reciprocal relations apply.

S. S. Penner, USA

1259. **Berlin, T. H., Witten, L., and Gersch, H. A., The imperfect gas,** *Phys. Rev.* (2) **92,** 1, 189–201, Oct. 1953.

This paper generalizes a "free volume" or cell model [Kirkwood, J. G., *J. chem. Phys.* **18,** p. 380, 1950] of liquid phase to include imperfect gas; free volume taken as equal to mean volume per atom, occupation numbers in cells taken as statistical variables. A novel and ingenious method is employed to sum partition function over occupation numbers. The model exhibits a critical temperature below which the isotherms become nonalytic with three pieces interpreted as phase transition from gas to liquid. The transition does not occur at constant pressure. This failure is thought to be due to arbitrary choice of free-volume size and may be remedied in further work under way. This reviewer suspects the model could be improved by including negative occupation numbers [Wooley, H. W., *J. chem. Phys.* **21,** p. 236, 1953; Kilpatrick, J. E., ibid., **21,** p. 1366, 1953], since the rigorous cluster theory of condensed systems [Mayer, J. E., ibid., **10,** p. 629, 1942; "Statistical mechanics," New York, John Wiley & Sons, 1940], in which any physical interpretation of the occupation numbers is quite superfluous, requires the occurrence of such negative values. The article gives no references to other closely related work [Siegert, A. J. F., *Phys. Rev.* **90,** p. 97, 1953; Reiss, H., *J. chem. Phys.* **20,** p. 1216, 1952; Rowlinson, J. S., and Curtiss, C. F., ibid., **19,** p. 1519, 1951].

W. Band, USA

1260. **Lenz, W., Thermodynamic basis of the new steam tables** (in German), *ZVDI* **95,** 27, 925–926, Sept. 1953.

Author considers the experimental and theoretical basis of the new Russian steam tables which were recently discussed by H. Erythropel [title source **94,** 1001–1004, 1952]. To facilitate the use of the formulas for specific volume v, enthalpy, entropy, and specific heats c_p and c_v, author derives power-series expansions in terms of $1/v$ with coefficients which are tabulated and depend on the quantity $T/100$, where T is the Kelvin temperature.

R. Heller, USA

1261. **Lee, J. F., Specific heat of gases at the critical point,** *ZAMP* **4,** 5, 401–404, 1953. (*See also* **Lee, J. F., The thermodynamics of critical phenomena in gases,** *J. Franklin Inst.* **256,** 3, 245–248, Sept. 1953.)

A determinate expression for sonic velocity at the critical point is derived in terms of isochoric specific heat, Joule-Thomson coefficient, molar volume, molecular weight, and temperature.

A similar but more general treatment of the same derivation was presented two years earlier by C. F. Curtiss, C. A. Boyd, and H. B. Palmer [*J. chem. Phys.* **19,** p. 801, 1951].

S. Gratch, USA

1262. **Town, G. G. D., Prediction of liquid-vapor equilibria from an empirical equation of state for mixtures,** Univ. Wisc. ONR-4, 14 pp., Aug. 1953.

A practical method has been developed by which one can determine the pressure-mole fraction curve of the liquid-gaseous phase boundary for a given temperature from an empirical equation of state.

The calculated results from author's equation of state, using the constants of the pure components in the equation, are in agreement with the experimental results of Palmer, Hirschfelder, and Boyd, but are in disagreement with the experimental results of Boomer, Johnson, and Piercey. From author's summary

1263. **Maslan, F. D., and Littman, T. M., Compressibility chart for hydrogen and inert gases,** *Indust. Engng. Chem.* **45,** 7, 1566–1568, July 1953.

1264. **A high temperature power station with a 610° C steam temperature: Tietz, H., Design; Buchholtz, H., Evaluation of boiler materials and wall thickness; Werner, M., and Ruttmann, W., Materials for boilers and pipelines; Schinn, R., Turbine materials; Buchholtz, H., Manufacturing of tube and headers and experience received; Tietz, H., Special problems; Werner, M., and Ruttmann, W., Protection of materials; Tietz, H., Attained operational experiences; Buchholtz, H., Schinn, R., and Tietz, H., Outlook** (in German), *ZVDI* **95,** 24, 801–831, Aug. 1953.

In the fall of 1951 the Siemens-Schuckert Company completed a superposition turbine and boiler installation at the Farbenfabriken Bayer AG in Leverkusen, Germany, which has now operated for over 10,000 hr. This series of articles gives the background of this installation and some of the operating results. The Benson boiler, mounted out of doors, delivers 280,000 lb/in.^{2} steam at a maximum pressure of 2600 lb/in.^{2} and 1132 F. The fuel is powdered coal. The single-rotation radial flow turbine exhausts at 440 lb/in.^{2} into an older low-pressure installation. The output at maximum flow is 11,400 kw. Bypass valves permit running the low-pressure turbine on steam from the Benson boiler.

The operating experience and the efficiency of the boiler plant are stated to have been satisfactory. Considerable apology is presented for the low turbine efficiency, but no actual test results are presented.

The articles contain much information of interest on the thinking in Germany in relation to materials at high temperatures and future construction of high-temperature, high-pressure power plants. The boiler appears as a significant experiment of value to future planning of power plants.

C. R. Soderberg, USA

1265. Bloomer, O. T., Gami, D. C., and Parent, J. D., Physical-chemical properties of methane-ethane mixtures, *Inst. Gas Technol. Res. Bull.* 22, 40 pp., July 1953.

Dew points and bubble points were measured through the pressure range of 50 psi to the critical pressure envelope for eight different compositions. Diagrams of phase composition against pressure and temperature and tables of K values were prepared. Isometric pressure-temperature measurements extended from the two-phase boundary to 90 F or 4000 psi for four different compositions. Compressibility charts were prepared and correlations of data with different equations of state were made. Experimental equipment and techniques are described. This information is useful for design and operation of de-ethanizers and other gas-handling equipment. J. D. Bush, USA

1266. Gastpar, J., European practice with Sulzer monotube steam generators, *Trans. ASME* **75,** 7, 1345–1362, Oct. 1953.

This paper describes a drumless-type steam generator in which the working medium passes only once through the total tube system. This type of steam generator has been developed in Europe and it seems that a large number have been installed there in sizes up to 465,000 lb/hr and with pressures up to 2100 psi. A few of the advantages given are that the high pressure parts can be reduced to a minimum and are practically limited to the heating surface; no drums are required, which seems to be a particular advantage in Europe due to difficulties in obtaining necessary materials; the load on the supporting structure can be reduced; the designer is given a larger measure of freedom in the disposition of the tube systems since the use of the natural buoyancy has been dispensed with and therefore no downcomer tubes are needed. R. M. Wingren, USA

1267. Fulton, S. D., A short method for the evaluation of the effect of some thermal-cycle variations on steam-turbine heat rates, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-97, 20 pp.

Author computes change of heat rates due to small variations in feed-water heating arrangement by considering the changes in input and output, assuming the "thermal efficiency from any extraction point to the turbine exhaust" as constant. Results are given in equations where differentials have been substituted by finite differences.

The idea of calculating only the small changes themselves instead of following through the whole series of computation including these changes is certainly sound. But reviewer cannot agree with author's reasoning in deriving the various equations. The presentation is typical of vague engineering papers and lacks scientific preciseness. There is no reason to call the enthalpy difference between extraction points as "used energy." The term "heat available," which sometimes degenerates simply into "heat (at certain point)," is never clearly defined. Such terms are entirely foreign to the rational thermodynamic concept. L. S. Dzung, Switzerland

Heat and Mass Transfer

(See also Revs. 1036, 1037, 1040, 1120, 1128, 1146, 1147, 1191, 1200, 1235, 1257, 1324, 1325)

1268. Baker, H. D., Ryder, E. A., and Baker, N. H., Temperature measurement in engineering, Vol. I, New York, John Wiley & Sons, Inc.; Chapman & Hall, Ltd., 1953, vii + 179 pp. $3.75.

The author's objective was to provide in convenient nonmathematical form the necessary background and descriptive information for use by an engineer interested in making temperature measurements. The first four chapters of vol. 1 cover introductory material for both volumes. The remaining portion of the first volume is related to the use of thermocouples for the measurement of internal temperatures of solids.

Chap. 5 covers such important concepts as parasitic effects, thermocouple wire and its calibration, junctions and splices, insulation, and thermocouple circuits. Chap. 7 discusses some phase of heat transfer to and from a thermocouple system. Considerable material is presented in chap. 8 on special designs for installing the thermocouple junction. Techniques such as welding, soldering, peening, etc., of junctions are also included in this section. Chap. 9 covers such items as drilling techniques, drill sharpening, lapping, etc. Protective coatings, heat and corrosion-resistant metals, plastics, nonmetallic refractories, and cements are discussed in chap. 10. Chaps. 11 and 12 introduce subjects such as the anchoring of the leads, arrangement of lead wires, temperature gradient, and heat flow as effected by lead-wire arrangements.

Many references are included at the end of several chapters, which enable the reader to delve more deeply into a particular subject. Considerable information of a practical nature is included in the book, which should prove to be of value to engineers concerned with the measurement of temperatures in solids.

G. A. Hawkins, USA

1269. Mason, H. L., Thermal conductivity of some industrial liquids from 0 to 100 C, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-40, 4 pp.

Because of discrepancies among published values for thermal conductivity of liquids, the Iowa Engineering Experiment Station undertook a series of thermal-conductivity measurements on a number of nonmetallic, noncorrosive, lower viscosity liquids, with the results reported in this paper. From author's summary

1270. Giannone, A., The distribution of temperature in large casts of concrete (in Italian), *Ingegnere* **27,** 7, 761–768, July 1953.

The nonuniform distribution of temperature within a large cast of concrete may cause considerable internal stresses. Thus it is of great practical importance to know the distribution of temperature as a function of time and of coordinates, considering, if necessary, the development of heat caused by hydration of cement.

Paper shows that the solution of this problem by the well-known Schmidt method is possible, and four particular problems are resolved: (1) Infinite wall of concrete of constant thickness submitted to external variations of temperature; (2) the same wall at constant external temperature (10°) with internal development of hydration heat; (3) infinite concrete block cast in successive layers of 1.8-m thickness each in intervals of three days; (4) concrete block of quadratic or rectangular section with arbitrary third dimension. Z. Horák, Czechoslovakia

1271. **Zatakis, H., A certain problem in heat conduction,** *J. appl. Phys.* **24,** 7, 895–896, July 1953.

A homogeneous sphere is surrounded by an infinite homogeneous medium. Heat is generated inside the sphere at a prescribed rate. The temperature distribution inside and outside the sphere is computed. From author's summary

1272. **Smith, R. C. T., Conduction of heat in the semi-infinite solid, with a short table of an important integral,** *Austral. J. Phys.* **6,** 2, 127–130, June 1953.

Solution of a problem in heat conduction is expressed in terms of integral $\int_0^U e^{-\alpha(1+u^2)}\, du/(1+u^2)$. Integral is tabulated for various values of α and U.

From author's summary by W. J. Anderson, USA

1273. **Tribus, M., and Klein, J., Forced convection from nonisothermal surfaces,** "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 211–235, 1953.

Authors give good review and bibliography of previous work on the subject. Paper reviews Rubesin's method of analyzing the problem and uses this method as well as the solutions of other investigators to treat the problem of distributed heat sources.

R. J. Mindak, USA

1274. **Deissler, R. G., Analysis of turbulent heat transfer and flow in the entrance regions of smooth passages,** *NACA TN* 3016, 88 pp., Oct. 1953.

Paper deals with the analytical calculation of heat-transfer coefficients for turbulent flow of air in the entrance regions of smooth tubes and parallel flat plates. Variations of density, viscosity, and thermal conductivity of the gas with temperature are duly accounted for in the case of uniform heat flux, uniform initial temperature distribution, and fully developed velocity profile. The specific heat and Prandtl number are taken as constants. Other cases of uniform initial velocity distribution are also investigated but with assumed constant fluid properties.

Velocity and temperature distribution in the boundary layer are obtained by integrating the usual differential equations for shear stress and heat transfer under the assumption that eddy diffusivities for momentum transfer and heat transfer are identical. For flow close to the wall, this results in two simultaneous integral equations which are solved by the method of iteration. Details were given in one of the author's previous publications [*NACA TN* 2629]. The growth of the thermal and flow boundary layer in the entrance region are calculated, respectively, from the well-known heat flow and momentum equations of the boundary layer.

Results of analysis include (1) the development of thermal boundary layer in the entrance region of a smooth tube due to turbulent flow of a gas; (2) variation of local and average heat-transfer coefficient, expressed in terms of Nusselt number, along the length of the tube at various Reynolds numbers and different rates of heat addition and extraction; (3) change of wall and bulk temperature; and (4) variation of average and local friction coefficient; all plotted against the ratio of the distance from entrance to the tube diameter.

Heat-transfer coefficients for liquid metals with $Pr = 0.01$ have also been calculated for the case of uniform heat flux, uniform initial temperature distribution, and fully developed velocity profile. Temperature profile obtained in one of author's previous papers [*NACA RM* E52F05] is used in the calculation. The result is given by plotting Nusselt number against Graetz number for various Peclet numbers.

Reviewer believes that this paper and others previously published by the author and his colleagues at the Lewis Flight Propulsion Laboratory contribute greatly to our knowledge on turbulent heat transfer. B. T. Chao, USA

1275. **Drake, R. M., Jr., Seban, R. A., Doughty, D. L., and Levy, S., Local heat-transfer coefficients on surface of an elliptical cylinder, axis ratio 1:3, in a high-speed air stream,** *Trans. ASME* **75,** 7, 1291–1302, Oct. 1953.

See AMR 6, Rev. 1985.

1276. **Boehm, J., Determination of design values of film coefficient of water vapor condensation on metallic walls** (in French), *Chaleur Industr.* **34,** 337, 209–214, Aug. 1953.

1277. **Fairbrother, J. A. V., Ratio of convection to conduction loss for a hot wire stretched along the axis of a vertical cylindrical tube,** *Brit. J. appl. Phys.* **4,** 7, 204–209, July 1953.

A mathematical analysis of a method for determining the thermal conductivity of a liquid or a gas is given. The method analyzed is that of measuring the temperature drop across the annular gap between a wire stretched along the axis of a vertical cylinder, which is filled with the substance to be studied, and the cylinder wall, for a known power dissipation in the wire. The cylinder is considered sufficiently long so that the end effects may be neglected. Furthermore, it is assumed that the radial temperature drop is approximated by

$$\theta = [Q_r \log (R/r)]/2\pi KL$$

where θ is the temperature drop between R and r, R is the radius of the cylinder, S is the radius of the wire, $S \leq r \leq R$, Q_r is the radial heat loss, K is the thermal conductivity, and L is the length of the cylinder, which applies when radial convection effects are absent. Two analyses are carried out; one for an open cylinder, the other for a closed cylinder.

For the open cylinder the ratio of axial heat loss to radial heat loss is given by

$$Q_a/Q_r = [\Theta\rho_0^2\alpha C_p g/4\eta K \log (R/S)] \int^R f_1 r \log (R/r)dr$$

where

$$f_1 = \{[(R^2 - S^2)/\log (R/S)] + r^2 - S^2\} \log (R/r) + r^2 - R^2$$

Θ is the temperature drop between R and S, ρ_0 is the density of the fluid at radius R, C_p is the specific heat, g is the acceleration due to gravity, α is the temperature coefficient of change of density, and η is the viscosity of the fluid.

For the closed cylinder it is further assumed that the return flow takes place under the Poiseuille conditions. The expression for Q_a/Q_r is given and is both contractable and usable, but not reproducible here. G. W. Evans, II, USA

1278. **Johnson, H. A., Hartnett, J. P., and Clabaugh, W. J., Heat transfer to molten lead-bismuth eutectic in turbulent pipe flow,** *Trans. ASME* **75,** 6, 1191–1198, Aug. 1953.

Paper presents experimental heat-transfer data for molten-lead-bismuth eutectic for turbulent flow in a $^3/_4$-in., 18-gage mild-steel tube with constant heat flux. Validity of the measurement technique is established indirectly by identical tests with water which agree with predicted heat transfer for that liquid. Results for lead bismuth are correlated for the Peclet modulus range of 200–500 over a Prandtl modulus range of 0.020 to 0.046 and Reynolds number range of 7500 to 170,000. The Nusselt moduli are 25 to 35% lower than the prediction by the Lyon-Martinelli momentum theory for turbulent flow.

From authors' summary by J. E. Brock, USA

1279. Levy, S., and Seban, R. A., Skin friction and heat transfer for laminar boundary-layer flow with variable properties and variable free-stream velocity, *J. appl. Mech.* **20, 3, 415–421, Sept. 1953.**

Numerical solutions of the momentum and energy equations are presented for particular types of laminar boundary-layer flow analogous to the Hartree "wedge flows." Variation of the viscosity and of the thermal conductivity is considered under the circumstances of no dissipation, favorable pressure gradient, and the product of conductivity and density a constant. The solution is based on approximate representations of the velocity and temperature profiles in the boundary layer and these are of such character that the labor of calculation is minimized and the accuracy of the results preserved. The differential equations are reduced to two algebraic equations which rapidly yield the skin friction and the heat transfer in terms of the wall to free-stream temperature ratio for the desired value of Prandtl number. Numerical results are given for a range of wedge flows with gases of Prandtl number 0.70 and 1.0. These results reveal that, when the free-stream velocity is variable, the temperature difference between the wall and the free stream exerts a substantial effect on the velocity distribution in the boundary layer and on the skin-friction coefficient. Alternatively, the heat-transfer coefficient is not affected radically. A calculation method is presented for the determination of the heat transfer and skin friction for a flow with an arbitrary variation of velocity over an isothermal surface. This method utilizes the results of the present analysis for the variable property wedge flows.

From authors' summary by G. A. Hawkins, USA

1280. Hickey, J. S., Jr., Heat transfer at high-power densities, *J. appl. Phys.* **24, 10, 1312–1317, Oct. 1953.**

Author describes the problems encountered in the design of liquid cooling systems for the dissipation of high heat-transfer rates at the anode of microwave tubes. The advantages and disadvantages of liquid metals over water as the cooling fluid are discussed. Data are presented covering the experimental work. Numerous figures describe parts of the apparatus used in the experiments. For the design of a system wherein the dissipation of energy is of the order of kilowatts per square centimeter, the author recommends that consideration be given to liquid metals as the coolant. G. A. Hawkins, USA

1281. Baer, D. H., Schlinger, W. G., Berry, V. J., and Sage, B. H., Temperature distribution in the wake of a heated sphere, *J. appl. Mech.*, **20, 3, 407–414, Sept. 1953.**

The temperature distribution in the wake of a heated sphere of 0.5-in. diam was determined at a gross stream velocity of 30 fps. Measurements were carried out in a channel 0.70 in. in height and 12 in. in width. The surface temperature of the sphere and the energy dissipation from it were determined as a function of gross stream velocities between 10 to 90 fps. The temperature distribution in the wake was correlated on the basis of methods developed for cylinders, and satisfactory agreement was obtained.

From authors' summary by W. L. Sibbitt, USA

1282. Kudryashev, L. I., Heat exchange in free convection with turbulent boundary layer (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 3, 441–449, Mar. 1953.

Author offers an approximate solution of problems dealing with heat transfer where free convections in a turbulent boundary layer are encountered.

The rigor of mathematics in solving such problems induced the author to apply a simplified hydrodynamic theory of heat transfer. The application of this theory is limited in scope, as its basis is unity of process for heat and mechanical energies. Existing experimental data do not offer a precise solution of such problems. However, investigations by M. A. Michaev and L. C. Aigerson concerning temperature spread of free-flowing air upon the height of vertical tubes permit deducing that, after a turbulent state is reached in a boundary layer, the heat-transfer coefficient remains constant. This experimental fact, according to the author, indicates the similarity of heat and hydrodynamic phenomena, within its limited scope.

The application of a simplified hydrodynamic theory offers semiempirical solution of heat-exchange problems involving free-flowing liquids with turbulent boundary layer.

Michaev's experimental results vary with the author's calculations from -4.4% to $+5.9\%$. Michaev's equations come close to a mean arithmetic value. W. Green, USA

1283. Schroeder, F.-K., Influence of measuring error upon experimentally determined over-all heat-transfer coefficient in surface condensers (in German), *Brennstoff-Wärme-Kraft* **5, 5, p. 154, May 1953.**

A detailed error analysis gives the error in the over-all coefficient as a function of the errors made in measuring the rate of water flow, the inlet and outlet water temperatures, and the saturation temperature of the steam. An error of 1.8F in the measurement of the saturation vapor pressure may produce errors greater than 30% in the over-all coefficient. W. L. Sibbitt, USA

1284. Yamagata, K., Hirano, F., Nishikawa, K., and Matsuoka, H., Nucleate boiling on horizontal heating surface, *Jap. Sci. Rev.* **2, 4, 409–420, Sept. 1952.**

In order to clarify the mechanism of heat transfer in nucleate boiling, many photographs were taken of steam bubbles generated on a horizontal heated plate (diam 100 mm) and fluctuation of the boundary layer, using light passing through water very near the heated surface; at the same time the temperature of a heated plate and the temperature distribution from the surface of plate to the water level were measured by thermocouples or an optical method. The experimented range of heat flux is from 6560 to 43,760 kcal/m²h.

The conclusions are: (1) The types of steam bubbles generated on the heating surfaces are of four types, namely, sphere type, bell type, procession type, and tandem type. The former two are simple bubbles and the latter two, multiple bubbles. Using distilled water, the rate of simple bubble generated on the heating surface decreases with increase of heat flux and, in case of city water, it is about 100% independent of heat flux.

(2) The flow in the boundary layer very near the heated surface varies with the type of steam bubbles.

(3) Heat flux below 9800 kcal/m²h corresponds to the free-convection region where the stirring effect of bubbles is small, and heat flux over 15,000 kcal/m²h corresponds to the forced-convection region where stirring effect is important; between them there is the transition region where free convection changes to forced convection.

(4) In the heat transfer to boiling liquid, the important factor controlling the coefficient of heat transfer is not the heat flux nor the temperature difference between the surface of a heated plate and boiling liquid, but the stirring effect of vapor bubbles.

(5) With no relation to type, size, and frequency of generating steam bubbles, the following relation in the first approximation was obtained: $Nu \propto n^{1/3}$. From authors' summary

1285. Livingood, J. N. B., and Eckert, E. R. G., Calculation of transpiration-cooled gas-turbine blades, *Trans. ASME* **75, 7, 1271–1278, Oct. 1953.**

Charts have been prepared by the authors which permit rapid

calculation of the wall temperature of a cooled blade. Charts are based on solutions previously published by the NACA for heat-transfer relationships as established by boundary-layer conditions for a permeable blade. Flow of air through the blade creates an insulating layer. The effectiveness of this air flow is a minimum at the stagnation point. The analysis neglects conduction through the metal which tends to cool this narrow region and so reduce the coolant flow required there.

The paper mentions the difficulties in actually obtaining the coolant-flow distribution indicated. The problem is complicated, but, in reviewer's opinion, the difficulties are likely to be in matters not considered in the paper, such as nonuniformity in the permeability of the blade material, relatively large pressure drop even for the 3% cooling air-flow rate mentioned by the authors, and a nonuniform temperature gradient in the metal normal to the surface. D. Aronson, USA

1286. **Eckert, E. R. G., and Livingood, J. N. B., Comparison of effectiveness of convection-, transpiration-, and film-cooling methods with air as coolant,** *NACA TN* 3010, 52 pp., Oct. 1953.

Various parts of aircraft propulsion engines that are in contact with hot gases often require cooling. Transpiration and film cooling, new methods that supposedly utilize cooling air more effectively than the conventional convection cooling, have already been proposed. The present report presents material necessary for a comparison of the cooling requirements of these two new methods with conventional convection cooling. Correlations that are regarded by the authors as the most reliable today are employed in evaluating each of the cooling processes.

Calculations for the special case in which the gas velocity is constant along the cooled wall (flat plate) are presented. These results should give a good indication of the relative effectiveness of the cooling methods under other flow conditions as well. Air is stipulated as the coolant and as the outside flow medium (a good approximation for combustion gases). Both laminar and turbulent flow, with and without radiation, are considered for Reynolds numbers between 10^3 and 10^9 and coolant-flow ratios from 0 to 0.012; for convection cooling, thermal effectiveness parameters of 0.6, 0.8, and 1.0 are included.

The calculations reveal that a comparison of the three cooling processes can be made on quite a general basis. The superiority of transpiration cooling is clearly shown for both laminar and turbulent flow. This superiority is reduced when the effects of radiation are included; for gas-turbine blades, however, there is evidence indicating that radiation may be neglected.

From authors' summary by S. Eskinazi, USA

1287. **Eckert, E. R. G., Transpiration and film cooling,** "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 195–210, 1953.

This very interesting paper discusses the fundamental physical processes connected with standard-convection cooling, film cooling, transpiration cooling, and film-evaporation cooling. These various cooling methods are then compared in regard to their effectiveness. For the case in which both the hot-gas stream and the coolant are air and the cooled wall is a flat plate, it is concluded that transpiration cooling is the most effective and produces the lowest wall temperature for a specified cooling air flow or, inversely, requires the smallest amount of coolant to cool the wall to a certain temperature. L. Goland, USA

1288. **Burton, E. J., Recent advances in radiation and immersion pyrometry,** *Instruments* **26,** 10, 1524–1525, Oct. 1953.

Recent advances in radiation and immersion pyrometry include (1) a reflecting-hemisphere radiation pyrometer for measuring surface temperatures of ingots, molds, and forgings in the range of 300 to 900 C; (2) a tungsten-molybdenum thermocouple immersion pyrometer for measuring liquid-steel temperatures up to 1850 C; and (3) a fixed-focus narrow-angle mirror pyrometer for measuring total radiation from furnace flames.

From author's summary

1289. **Fox, L. L., Palmer, P. L., and Whittaker, D., Sampling errors in radiation measurement using the moll thermopile method,** *Brit. J. appl. Phys.* **4,** 9, 273–287, Sept. 1953.

Paper deals with experiments on the selection of sampling positions for routine measurement of radiant heat output of solid-fuel open fires. The thermal radiant energy was measured by means of a series of thermopiles installed on a radiometer arc capable of being rotated about its vertical diameter. The arc has a radius of 3 feet, its center being at that of the fire. Effective sensitivities of the thermopiles were made identical by introducing suitable resistance in parallel with each pile. Results of measurement given by various combinations of latitude and longitude sampling arrangements were tabulated and compared with those obtained from a "sub-standard" consisting of 21 Russell latitudes and 27 Russell longitudes. It was found that the number of sampling positions could be reduced to 5 Russell latitudes and 5 Russell longitudes while still retaining an accuracy of about 1%.

B. T. Chao, USA

1290. **Luck, G., Depth effect in drying with thermal radiation** (in German), *Forsch. Geb. Ing.-Wes.* **19,** 3, 88–91, 1953.

Author solves mathematical problem of temperature distribution resulting from steady-state heat conduction in a partially transparent slab that receives radiant energy from both sides and loses heat to surroundings by convection from both faces. Plots constructed from the resulting equation show calculated internal temperature profiles evaluated for certain specific values of material properties and radiation intensities.

The mathematical approximations made do not allow for changes in the material properties as drying proceeds or for the properly large influence of vaporization of liquid at surface and internally. R. L. Pigford, USA

1291. **Neel, C. B., Jr., An investigation utilizing an electrical analogue of cyclic de-icing of hollow steel propellers with internal electric heaters,** *NACA TN* 3025, 31 pp., Oct. 1953.

An analytical investigation of heaters used for propeller protection against ice; a de-icer superior to present types may be constructed. Continuation of work by Neel in *NACA TN* 2852 [AMR **6,** Rev. 2613]. M. Tribus, USA

1292. **Lowell, H. H., Maximum evaporation rates of water droplets approaching obstacles in the atmosphere under icing conditions,** *NACA TN* 3024, 56 pp., Oct. 1953.

From a stepwise integration of the evaporation equations for a droplet suspended in an air stream, the author verifies Langmuir's original conclusion that, at conventional flight speeds with conventional sized wings, negligible droplet evaporation occurs. Inlet ducts 10 ft long, near 0 C at high ram pressure, may evaporate 50% of the water in small drops. In general, however, little design error occurs due to evaporation. M. Tribus, USA

1293. **Callaghan, E. E., Analogy between mass and heat transfer with turbulent flow,** *NACA TN* 3045, 19 pp., Oct. 1953.

Author uses Prandtl's simplified concept of the turbulent boundary layer as a basis for deriving expressions for rates of heat and mass transfer with gas flowing past a flat plate. The ratio of

the velocity at the outer edge of the laminar layer to the free-stream velocity, necessary in the Prandtl analysis, is obtained from the equation given by Donaldson [*NACA TN* 2692, 1952].

To obtain absolute values of heat- or mass-transfer coefficients by the author's equations, values must be known for the exponent of the boundary-layer power-law profile. It is shown that the ratio of the Stanton number for mass transfer to that for heat transfer is insensitive both to the value of the power-law exponent and to the Reynolds number. An average value of this ratio for the air-water system is computed to be 1.05, which is in good agreement with experimental results obtained by others. The author shows that the results of the analysis are valid up to Mach numbers of 2. L. M. K. Boelter, USA

1294. Clusius, K., Results of low temperature research, a plant for the liquefaction of technically pure hydrogen (in German), *Z. Naturforsch.* **8**, 8, 479–493, Aug. 1953.

1295. Cadiergues, R., The permeability of structures to air, gas, and vapors (in French), *Ann. Inst. tech. Bât. Trav. publics* **6**, 69, series 37, 809–835, Sept. 1953.

Author gives numerical information on permeability to air and to vapor of materials, of fixed structures with dry joints, and of movable elements (windows, doors, etc.). He also gives general permeability formulas and includes a bibliography.

C. Codegone, Italy

1296. Rossie, K., Diffusion of water vapor into air at temperatures up to 300° C (in German), *Forsch. Geb. Ing.-Wes.* **19**, 2, 49–58, Aug. 1953.

Author gives detailed description of measurements of the diffusion coefficient of water vapor into air at temperatures from 80 C to 300 C by a new stationary method, which avoids several disadvantages of previous methods. Extrapolated results agree well with measurements existing in the region from 0 to 100 C. The coefficient of diffusion was found independent of the concentration in these experiments and in the diffusion of water vapor into CO_2. P. Kriezis, Greece

1297. Bowden, A. T., and Hryniszak, W., The rotary regenerative air preheater for gas turbines, *Trans. ASME* **75**, 5, 767–776, July 1953.

Paper deals with the periodic-flow type of rotary regenerator for use as an air preheater in a simple open-cycle gas turbine in which the regenerative cycle efficiency can be exhibited as a function of the internal temperature efficiency of the rotor (matrix). A discussion of corrugated plate and wire gauze-type matrix performance is given, along with quantitative results for cycle power losses as affected by rotor dimensions, rotor speed, optimum gas-side-area to air-side-area ratio and optimum inlet-area to matrix-area ratio. The design problem of sealing is pointed up as a practical criterion for judging the relative merits of regenerative and recuperative-type heat exchangers.

For a companion paper by other authors, see AMR **6**, Rev. 2612. P. J. Schneider, USA

1298. Hahnemann, H. W., Temperature effectiveness of heat exchangers with regard to heat conduction in longitudinal direction. Part I (in German), *Forsch. Geb. Ing.-Wes.* **19**, 3, 81–87, 1953.

Paper deals with a particular aspect in the complex theory of the regenerative-type heat exchanger. In this type, heat is periodically transferred from a hot fluid and stored in the solid matrix of the heat exchanger. Subsequently, it is transmitted from the matrix to a cold fluid. Hot and cold fluids are either ducted alternately through the exchanger or the matrix is rotated through the hot and cold stream. Present paper considers the influence of the heat-conduction process within the solid matrix material parallel to the direction of the fluid flow. The temperatures of the two fluids and of the solid matrix as a function of distance from the entrance cross section are calculated for a simplified model of the actual process, which neglects time fluctuations of the temperatures, temperature differences within cross sections normal to the flow direction, and local or time variations of the heat-transfer coefficients. Engineering applications of this theory, which, in spite of the simplifications becomes rather involved, are promised as the content of a future paper. E. R. G. Eckert, USA

1299. Devyatov, B. N., Unstationary processes in continuously acting heat exchangers (recuperators) (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **90**, 5, 771–774, 1953.

Author considers distribution of the temperature in a continuously acting heat exchanger. Differential equations are derived for determination of temperatures $u(x, t)$ and $v(x, t)$ of the crossflow and counterflow, respectively. Applicability of Laplace transform when general initial and boundary conditions are given is pointed out. As an example, determination of temperatures $u(x, t)$ and $v(x, t)$ is shown for the case of an impulse excitation, when velocities w_1' and w_2' of the crossflow and counterflow, corresponding to a stationary state $u(x)$, $v(x)$, take a sudden change (by jump) to values w_1, w_2.

Finally, author points out the applicability of his method to other problems touching processes in similar-acting apparatus (absorbers, extractors, etc.) K. Rektorys, Czechoslovakia

1300. Eckert, E. R. G., Temperature distribution in the walls of heat exchangers with noncircular flow passages, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 703–718, 1953.

See AMR **6**, Rev. 1063.

Acoustics

(See also Revs. 1027, 1115, 1160, 1243)

1301. Bleich, H. H., and Baron, M. L., Free and forced vibrations of an infinitely long cylindrical shell in an infinite acoustic medium, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-37, 11 pp.

Extensive discussion of title problem with some discussion of acoustic radiation in a medium such as water. Solution is based on modes of shells in vacua [Rev. 1006 in this issue] as generalized coordinates. Results are of interest to specialists; solution involves standard methods. Relative simplicity of solution depends on mode shape functions of the shell satisfying the wave equation at the inner boundary of the acoustic medium [see also AMR **5**, Rev. 3574; AMR **6**, Revs. 661, 736].

R. Plunkett, USA

1302. Meecham, W. C., Propagation of radiation in an inhomogeneous medium near an irregular surface, *J. acoust. Soc. Amer.* **25**, 5, p. 1012, Sept. 1953.

Author uses ray theory to analyze propagation of sound in a semi-infinite fluid medium bounded by an irregular surface. A sound-velocity-depth relation is assumed such that rays initially making less than a certain angle with the surface are bent up-

ward, by virtue of Snell's law; such rays are propagated in a surface layer by successive reflections from the surface. Author calculates attenuation distance for various surface scattering models and finds that results are fairly independent of the model assumed. M. C. Junger, USA

1303. Monson, H. O., Intensities produced by jet-type ultrasonic vibrators, *J. acoust. Soc. Amer.* **25,** 5, 1007–1009, Sept. 1953.

Paper includes material adapted from author's Ph.D. thesis on "Investigation of ultrasonic smoke coagulation." Author mentions J. Hartmann's monograph [*IngenVidensk. Skr.* **15,** p. 97, 1939] in which some experimental results were presented. For his experimental work on the practical application of jet-type ultrasonic vibrators, there was, however, a need for further experimental data. Author tried out a series of generators with the same nozzle but different cup. Results are given of the influence of cup diameter, ratio *cup depth/cup diam* and ratio *cup diam/nozzle diam* with increasing inlet nozzle pressure.

The influence of the variation in ratio of cup to nozzle distance on the intensity is shown; some instability may occur by small fluctuations in pressure and temperature at the inlet of the nozzle.

Maximum intensity is reached with a ratio of *cup diam/nozzle diam* of 1.27. Ratios much greater than 1.27 completely preclude wave generation. The ratio of *cup depth/cup diam* sharply influences the intensity; author suggests a critical ratio beyond which intensity decreases rapidly but no experimental data are given. Intensities for cups 1 and 2 are higher than Hartmann's results.

In the table, figures are given of the highest maximum power outputs computed with the aid of data found by measuring the intensities at different positions surrounding the generator and by making traverses. Author states that the values of intensity and frequency are promising for the use of the jet-type vibrator for the ultrasonic coagulation of smoke. B. Schuil, Holland

1304. Thurston, G. B., and Wood, J. K., End corrections for a concentric circular orifice in a circular tube, *J. acoust. Soc. Amer.* **25,** 5, 861–863, Sept. 1953.

The results of an experimental investigation of the end corrections for acoustic resistance and acoustic inertance for a concentric circular opening in a partition in a circular tube are presented. The end corrections are taken to be that length which must be added to the geometrical length of the orifice when introduced into an expression for the acoustic impedance. This expression can be derived on consideration of a tube of infinite length filled with a viscous, incompressible fluid. Used in this manner, the two end corrections are found to take on the same values, these values agreeing with those derived for inertance on the basis of the mass contribution due to higher-order waves in the tube, treating the orifice as a plane piston source. Graphical criteria for the onset of measurable nonlinearity are presented.

From authors' summary

1305. Wood, J. K., and Thurston, G. B., Acoustic impedance of rectangular tubes, *J. acoust. Soc. Amer.* **25,** 5, 858–860, Sept. 1953.

Considering periodic flow in an incompressible viscous fluid, the authors derive an expression for the acoustic impedance of a section of parallel planes of infinite extent. To test the theoretical results obtained, measurements of acoustic resistance and inertance of narrow rectangular tubes and of slits were made at various frequencies in a hydrodynamical test system, the fluid used being water at 27 C. Good agreement was obtained by use of the proper end correlations [Ingård and Pridmore-Brown, title source, **23,** 6, 689–694, 1951], the ratio of effective length to geometric length ranging from 1.04 to 3.72. The results are shown in tables and graphs. R. Heller, USA

1306. Ting, L., Diffraction and reflection of weak shocks by structures, *J. Math. Phys.* **32,** 2/3, 102–116, July/Oct. 1953.

Weak shock (i.e., sound wave) normally incident on semi-rectangular barrier mounted on infinite plane (equivalent to complete rectangular barrier by symmetry, although author does not mention this) is attacked by Evvard's method [*NACA TN* 1382; AMR **1,** Rev. 688; *NACA TR* 951; AMR **4,** Rev. 3310]. Solution for finite barrier is obtained only during time interval required for wave to travel barrier width. Solution for very thin barrier is obtained for interval corresponding to thrice barrier height. Latter problem is identical with diffraction of pulse by strip [E. N. Fox, AMR **2,** Rev. 528] for which complete time history of total force has been obtained by reviewer [AMR **7,** Rev. 189]. J. W. Miles, USA

1307. Caro, D. E., and Martin, L. H., The velocity of sound in air at low pressures, *Proc. phys. Soc. Lond.* (*B*) 66, 405, part 9, 760–768, Sept. 1953.

The speed of propagation v of plane sound waves was measured in steel tubes filled with dry air free from carbon dioxide at room temperature. The range of pressure p extended from atmospheric down to 5 mm of Hg, 37 well-spaced values being employed. Frequencies of 250 cps and 1000 cps were used, and the time of transit of a sinusoidal pulse between two condenser microphones, mounted in the wall of the tube and separated by an accurately known distance of approximately 4 meters, was obtained with high precision with the aid of a double-beam cathode-ray oscilloscope. The observed velocities were first reduced to 20 C; then allowance was made for (a) gas imperfection, (b) attenuation, (c) wall flexure, (d) tube correction (derived from the least-squares value of K in $v = v_\infty - Kp^{-1/2} + Lp^{-1}$), (e) gas slip at the tube walls (derived from L). The correction term (d) was found nearly 10% less than the theoretical value. The weighted mean speed in free space at 20 C from both experiments is 343.40 ± 0.02 m/sec, in excellent agreement with the generally accepted value for air at ordinary pressure.

Within the limits of experimental accuracy, the speed of sound in air is found to be independent of the pressure down to 5 mm of Hg, there being no evidence of the increase in speed at low pressures as reported by Abbey and Barlow [AMR **2,** Rev. 686] and by Maulard [AMR **4,** Rev. 2790], an increase which (if real) would be of meteorological significance.

R. Heller, USA

1308. Plunkett, R., Experimental measurement of mechanical impedance or mobility, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-45, 5 pp.

A device for the experimental measurement of mechanical impedance as a function of frequency is described. The measured values for two systems are shown. It is also shown that the performance of a modified system may be predicted in some respects. These measurements show that this function is extremely complex and that the systems are very limber at audio-frequencies. From author's summary

1309. Sette, D., and Hubbard, J. C., Note on thermal relaxation of CO_2 in presence of H_2O and D_2O molecules, *J. acoust. Soc. Amer.* **25, 5, 994–996, Sept. 1953.**

Owing to the finite relaxation time associated with the vibration of polyatomic gaseous molecules, the velocity of sound will change with frequency and ambient pressure. When water vapor is added to carbon dioxide gas, there is considerable deviation from the change expected for the pure gas. The present experimental study indicates that the deviation cannot be explained by absorption or by assuming, in addition to the bending vibration of the O-C-O molecule, a symmetrical valence vibration. By using both H_2O and D_2O, it was also shown that the interaction with CO_2 does not involve energy transfer between bending of the latter molecule and rotation of the water vapor molecule. The differences between the actions of H_2O and D_2O are apparently due to a mass effect. V. Salmon, USA

1310. Exner, M. L., and Hampe, W., Experimental determination of the damping of pulsating air bubbles in water, *Acustica* **3, 2, 67–72, 1953.**

The damping of resonant radial oscillations of air bubbles in water and other liquids was determined experimentally in the frequency range 20 to 130 kcs. The method employed was to measure the reflection coefficient of the bubbles in a liquid-filled tube through which sound pulses were transmitted. The resonant frequencies and the diameters of the bubbles were also measured. Observed results for "normal" bubbles in water and in liquids of low viscosity and surface tension agreed with theory both as to resonant frequency and as to total damping from sound reradiation, heat conduction, and viscosity effects. "Anomalous" bubbles were observed in water whose decrement versus diameter agreed with theory, but whose resonant frequencies were higher. Dust particles were observed adhering to the anomalous bubbles. Damping of bubbles in a high-viscosity liquid was observed to agree with theory for sound radiation and heat conduction alone and to be considerably less than that predicted by Lamb from viscosity effects. The rise in resonant frequency associated with dust particles and the disagreement between theory and experiment relative to viscous damping are not explained. F. G. Blake, Jr., USA

1311. Lange, T., Measurement of step-sound insulation from ceiling with sinusoidal excitation (in German), *Acustica* **3,** 3, 161–168, 1953.

Impact sound transmitted from one room to another may be generated in a reproducible manner by a falling-hammer machine, as the type standardized in Europe. Author shows that results obtained with sinusoidal excitation by a special moving-coil vibration motor agree with those from the hammer source, when the spectral composition of the impact is known.

V. Salmon, USA

1312. Zwislocki, J., Wave motion in the cochlea caused by bone conduction, *J. acoust. Soc. Amer.* **25, 5, 986–989, Sept. 1953.**

Mechanics of inner ear is analyzed to explain compensation of bone-conducted sounds by air-conducted sounds. Assuming pressure difference between oval and round windows uniquely determines the cochlear vibrational pattern and makes compensation possible. Other experiments indicate the truth of this assumption. Author attempts mathematical justification, showing any pressure difference across membrane creates vibration whose wave length is independent of the source location. Hamilton's principle is interpreted to suggest that the wave always travels in the same direction. Reviewer feels the hidden and incompletely discussed assumptions limit the value of the paper.

E. Ackerman, USA

Soil Mechanics, Seepage

(See also Revs. 1011, 1029)

THE FOLLOWING PAPERS (REVS. 1313–1321) WERE PUBLISHED IN *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, in 3 vols. 75 SFr per set.

1313. Mogami, T., The behaviour of soil during vibration, vol. I, 152–155.

Small-scale experiments with soils subjected to vertical sinusoidal vibrations are described. Sand and loam specimens enclosed in metal containers were shaken on an electromagnetic vibration table. The results indicate that acceleration is a decisive factor in causing turbulence or "liquefaction." The shearing strength of sand and loam decreases with acceleration almost to zero, which justifies the expression liquefaction. This effect is, however, strikingly changed by the slightest surcharges.

[Remark of the discusser: Results of the next report, which promises the inclusion of surcharges and should be extended to variations in moisture contents, will be of great interest.]

R. K. Bernhard, USA

1314. Peltier, R., Measurement of the capillarity characteristics of soils by the Central Laboratory of bridges and roads (in French), vol. I, 173–177.

Paper covers measurements of capillary potential h and capillary permeability K different from seepage permeability by four different methods. Simplest test gives only product $K \cdot h$ by measuring weight of absorbed water at different intervals after porosity N is established and extreme conditions of infinite gradient at column height zero are eliminated. In situ test, also described and analyzed completely, gives same results. Apparatus consisting of U-tube, developed by author's laboratory, allows the reading of velocity of water at various potentials and permits separation of unknown factors. Last method, which is useful on special soils, consists of separating variables by making sample a composite of a known soil layer overlaid by the one to be studied. First two methods are less interesting and new than third, which will be particularly useful in road laboratory work in frost-heaving regions. R. Quintal, Canada

1315. Davis, F. J., Quality control of earth embankments, vol. I, 218–224.

Author describes basic statistical techniques pertinent to the quality control of earthwork. Concepts such as frequency distribution, standard deviation, and normal distribution are explained and procedures for utilizing these data are outlined. A generous number of illustrations are offered of actual applications to the control of density and moisture content.

W. L. Orr, USA

1316. Mandel, J., Settlement of a saturated layer of clay under the effect of a point load acting on the surface of the soil (in French), vol. I, 413–417.

Author derives the time-settlement relation for a layer of clay covered with a layer of sand to surface of which is applied a vertical point load. Certain simplifications are introduced,

notably to the boundary conditions on the upper surface of the clay, and the solution is presented in the form of charts for the case of a clay layer of infinite thickness. For a thin layer the results are identical with Terzaghi's solution.

R. E. Gibson, England

1317. **Cooling, L. F., Measurements of loads and strains in earth supporting structures,** vol. II, 162–166.

Paper gives a brief survey of methods used over the past ten years for the field measurement of loads and strains in structures supporting clay. These include both timbered and steel-sheet piled excavations and tunnels. Typical results obtained in various field investigations are included. From author's summary

1318. **Hansen, J. B., A general earth pressure theory,** vol. II, 170–174.

The main principles of a new method for calculating earth pressures are described. The method is based upon Kötter's equation and a special boundary condition developed by the author. The new method makes it possible to deal with more or less complicated "rupture figures" involving curved rupture lines. Applications are made to design of an anchored sheet wall and a cellular cofferdam. G. Pickett, USA

1319. **Bažant, Z., Jr., Stability of a non-cohesive soil under elliptic upward seepage,** vol. II, 198–203.

In a flow field downstream an apron of a weir, the stability of the ground body is studied mathematically. Besides the usual simplifications, cylindrical surfaces of sliding through the toe of the apron are assumed.

Author states that computations agree satisfactorily with experimental results. The latter are described too briefly to give evidence. H. J. Schoemaker, Holland

1320. **Edelman, T., The influence of the compressibility of soil on some problems of ground-water flow,** vol. II, 219–223.

An analysis is given which attempts to take into account the effect of soil compressibility on the permeability as the ground water level is raised or lowered. It is demonstrated that the piezometer test is not affected by soil compressibility and is, therefore, a valid test for measuring the permeability of any soil layer. This method was given by Luthin and Kirkham [*Soil Sci.* 86, 5, Nov. 1949]. E. Vey, USA

1321. **Habib, P., and Sabarly, F., Study of water circulation in a permeable soil by means of three-dimensional electrical analogy** (in French), vol. II, 250–254.

The methods described in this short article make one more addition to the many tools now available to engineers for solving problems of three-dimensional flow. The situation described is a common one very frequently met in construction on the water front. However, it is reviewer's feeling that such approaches should be regarded as substantiating laboratory demonstrations rather than recommended engineering approaches.

The problems in determining the true relation of horizontal and vertical permeability of soil deposits of a heterogeneous nature have not been answered to the nicety implied by the authors' statements. K. N. Hendrickson, USA

1322. **Tettinek, W., Settling versus time diagram of clay layers** (in German), *Öst. Bauzeitschr.* **8,** 7, 128–130, July 1953.

Based on standard consolidation theory, a double-logarithmic diagram is presented relating the time for various degrees of settlement and moduli of compressibility with the coefficient of permeability of the soil. Since in practice this coefficient is derived from the experimental coefficient of consolidation, it would have been preferable to base the diagram on the latter coefficient. G. G. Meyerhof, Canada

1323. **Verigin, N. N., Movement of moisture in soil** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **89,** 2, 229–232, Mar. 1953.

In soils penetrated by air the movement of moisture usually takes place when the pores are not completely filled, and is due either to cohesion or to gravity. Cohesive moisture is basically moved by absorptive forces causing its displacement from thicker to thinner layers. These forces are defined by gradient of moisture. The movement of moisture is also caused by thermo-capillary and thermo-osmotic forces, and by saline diffusion. Free or gravity moisture moves under forces of gravity and capillarity caused by surface stresses of water in narrow channels of pores and by evaporation.

The paper deals with movement of moisture of constant temperature and salinity, caused only by gravity, absorption, and capillarity. If both cohesive and free water move simultaneously in soil, free water can change into cohesive water. This will depend on molecular humidity of the soil. The problems are presented in differential equations and concluded in two basic characteristics of movement of the moisture in soil: (1) Transition of free into cohesive moisture causes considerable delay of the movement; (2) if the cohesion of free moisture in soil decreases, the resistance against movement will sharply increase. Other results clarify laboratory and field tests. Reference is made to research by A. V. Likov, B. V. Deriagin, E. Koliasev, K. Melnikov, S. F. Averianov, L. S. Leibenson, N. N. Bindeman, A. A. Rode, A. I. Budaronskiy, B. A. Kin, R. A. Fisher, W. B. Haines, and others.

Referring to papers by L. S. Leybenson, P. Ya. Polubarinova-Kochina, and S. A. Christianovich, author presents and discusses a new system of differential equations which can be used also for plano-radial and sphero-radial filtration. To the author's knowledge, the available literature refers only to linear law of filtration, and other types of fluid flow have not yet been theoretically studied. J. J. Polivka, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 1221, 1253, 1292, 1302)

1324. **Dufay, J., Berthier, P., and Morignat, B., New evaluation of the altitude of the atmospheric layer which emits a green ray of oxygen in the light of the night sky** (in French), *C. R. Acad. Sci. Paris* **237,** 15, 828–830, Oct. 1953.

Carefully made spectro-photographic measurements comparing the intensity of the green oxygen line at a zenith distance of 78.5° to that at 11.5° gives the height of emission of the line between 200–250 km.

The measurements were made using a two-prism spectrograph with large light-gathering power and dispersion. Results were corrected for absorption within the lens system, diffusion by atmospheric constituents, and the continuous spectrum forming the background. Agreement with most other photoelectric and photographic determinations of the altitude was good. It is thus established that the altitude of emission of this line is too high for it to be excited by triple collisions, as predicted by the theory of Chapman [*Phil. Mag.* **23,** p. 657, 1937].

Joanne S. Malkus, USA

1325. Pleijel, G., The Globoscope, *IngenVetensk Akad. Tidsk. Tekn. Forsk.* **24,** 6, 267–270, 1953.

The Globoscope is an instrument for the determination in situ of the times of sun radiation and the quantities of radiation from sun and sky. From author's summary

1326. Rouaud, A., Theoretical study of thermal insulation of a radiosonde (in French), *J. sci. Météor.* **5,** 18, 57–74, Apr.-June 1953.

Author examines the conditions to be realized by thermic insulation of the installation of a radio-sounding device so that the temperature adjustment of barometric capsula becomes negligible. From author's summary

1327. Saïssac, J., Measurement of turbulent diffusivity of the atmosphere (in French), *J. sci. Météor.* **5,** 18, 49–56, Apr.-June 1953.

Two methods are set out for determination of turbulent diffusivity: One concerns the layer of air near to the ground; the other is relative to layers above, to a height of the region of 3000 m. The scale idea is underlined in the physical sense given to those measures. From author's summary

1328. Smagorinsky, J., The dynamical influence of large-scale heat sources and sinks on the quasi-stationary mean motions of the atmosphere, *Quart. J. roy. meteor. Soc.* **79,** 341, 342–366, July 1953.

The results of classic convective theory concerning meridional circulation encountered many difficulties in view of recent data available, and horizontal mixing theory has taken the place of the classic one. In this paper, author suggests that not only for the case of general circulation does the classic convective theory fail to explain the phenomena of large-scale monsoon. He developed the quasi-static and quasi-geostrophic dynamic theory and determined stationary perturbation motion consistent with given distribution of heat sources and sinks. As compared with observation, his results seem to be more valid than those of convective theory. But there is scanty information concerning the distribution of heat sources and sinks in the atmosphere, and the observed perturbed motion involves the effect of orography which is, at least, comparable with nonadiabatic one; hence, it is hard to check the validity of this theory sufficiently. But it is worth notice that author applied the method of recent dynamic meteorology to the case of nonadiabatic phenomena.

H. Arakawa, Japan

1329. Gustafson, A. F., On anomalous winds in the free atmosphere, *Bull. Amer. meteor. Soc.* **34,** 5, 196–201, May 1953.

From two solutions of normal (quadratic) equation for horizontal nonviscous motion in rotating frame, a critical wind velocity in anticyclonic trajectory is found, viz., $V_c = 2V_g \cos\beta$, where V_g is geostrophic velocity and β angle of geostrophic deviation. Second solution yields anomalous winds with speed $V > V_c$. Author further demonstrates occurrence of geostrophic deviations and, in particular, of anomalous winds at 10,000-ft level at significant places in rapidly moving large-scale anticyclonic patterns. Limited vertical extent of phenomenon in analyzed cases is stressed. Possible explanation as suggested by author disregards, however, nontraversability of singularity $V = V_c$, clearly demonstrated in case of the well-known gradient wind solutions having same form as author's. [See D. Brunt, "Physical and dynamical meteorology," 1939, § 115.] Development of anomalous winds from subcritical flow by continuous adjustment to a rapidly changing pressure field is therefore, in reviewer's opinion, physically impossible in large-scale motion.

F. A. Berson, Australia

1330. Takeuchi, M., The motion of tropical cyclones in a nonuniform flow field, *Pap. Meteor. Geophys.* **3,** 4, 252–268, Mar. 1953.

The motion of tropical cyclones in a circular or hyperbolic general flow with uniform vorticity is treated. The motion in a linear flow is also dealt with for the sake of comparison with the results of several authors.

The quantitative formulation of the steering principle is attempted. The motion will trace a trochoid in a linear flow, an epicyclic in a circular flow, and a similar trace in a hyperbolic flow.

The amplitude and period of oscillation depend on the wind speed of the basic current and on the size and intensity of the storm, and not on the Coriolis parameter. Both the speed and direction of a tropical cyclone are considerably affected by such oscillating motion. The storm will sometimes describe a loop path as a result of the oscillation.

Partly from author's summary by H. Arakawa, Japan

1331. McDonald, J. E., Remarks on the development of the Coriolis principle, *Bull. Amer. meteor. Soc.* **34,** 5, 192–215, May 1953.

1332. Smebye, S. J., Tendency computations with a continuous two-parametric atmospheric model, *Tellus* **5,** 2, 219–223, May 1953.

In a case of strong development, the tendencies at the 500- and 1000-mb surfaces are computed with a two-parameter model. It is possible to take the thermal structure of the atmosphere into account in a crude manner by expressing the vertical temperature distribution as a function of the deviation of the 1000-to-500-mb thickness from a standard value. The height of the 500-mb surface and the 1000-to-500-mb thickness are used as variables. The tendencies are computed for two maps 12 hr apart, the intermediate tendencies interpolated for every 2 hr, and the 12-hr change of the 1000- and 500-mb surfaces are then computed. The tendencies computed represent an improvement over those computed with the barotropic model, but the 12-hr changes are still only about two thirds of the observed changes.

From author's summary by W. C. Johnson, USA

1333. Sakuraba, S., The relation between a closed energy system and an open energy system, *Geophys. Mag. Tokyo* 24, 4, 209–218, Mar. 1953.

Author constructs schematic energy budgets for models of open atmospheric system with inflow (or outflow) in the friction layer, vertical motion in the center, and outflow (or inflow) aloft. The one system represents a tropical cyclone, the other an anticyclone. These are combined and the energy budget for the closed system is exhibited. M. Wurtele, USA

1334. Hollmann, G., Contribution to the theory of cyclones (in German), *Meteor. Rdsch.* **6,** 3/4, 41–45, Mar./Apr. 1953.

Certain dynamic properties of moving cyclones were discussed by applying the pressure-averaged or integrated vorticity equation, without using the thermodynamic equation. The motion is decomposed into a mean motion $u(\rho)$, which is uniform in the isobaric surfaces and varies with pressure, and a disturbance $\vec{v}^*(x, y, p, t)$. It is shown that if the axis of the disturbance is vertical, the disturbance will be propagated with a phase velocity equal to the

amplitude-weighted mean velocity $\bar{u}$ without changing shape. If, on the other hand, the axis of the disturbance inclines upward and westward, then the disturbance will grow exponentially with time t. This instability characteristic of the motion is expressed in terms of the phase velocity instead of the wave length. The study shows that if the baroclinic property of the atmosphere is taken into consideration, the vorticity equation is able to give the development of weather. However, the vorticity equation itself is not sufficient to determine the motion. For example, the vertical variation of amplitude and phase of the disturbance cannot be derived from the vorticity equation alone. Other studies have shown that when the thermodynamic equation is used together with the vorticity equation, then these properties of the disturbances are also represented by the solution.

H. L. Kuo, USA

1335. Roulleau, J., The height of the atmospheric friction layer over the ocean (in French), *J. sci. Météor.* **4**, 16, 135–142, Oct.-Dec. 1952.

The height of the friction layer is defined by the author as the height at which the curve of the wind speed vs. height becomes linear. The mean wind speed derived from 283 soundings from the weather ship located at 45° N, 16° W was used. Author finds very good agreement with the theoretical curve of Taylor. The effect of wind direction seemed negligible.

The study was extended to the North Atlantic data obtained from the Meteor and Deutsche Seewarte expedition. The height was found to vary with latitude, approximately 300 m at 150° N to 650 m at 10° N.

Some indications of the variability in time of the height are also given. W. P. Elliott, USA

1336. Hamilton, E. L., and Andrews, L. A., Control of evaporation from rain gages by oil, *Bull. Amer. meteor. Soc.* **34**, 5, 202–204, May 1953.

1337. Satô, Y., Study on surface waves. VIII. Nomogram for the phase velocity of Love-waves and maximum thickness of the surface layer, *Bull. Earthq. Res. Inst., Tokyo Univ.* **31**, part 2, 81–87, 1953.

Nomograms are presented for the calculation of (a) the phase velocity of Love waves when the physical data are given and (b) the maximum possible thickness of the upper layer when only incomplete physical data are available. H. G. Hopkins, USA

1338. Satô, Y., Study on surface waves. VII. Travel-time of Love-waves, *Bull. Earthq. Res. Inst., Tokyo Univ.* **30**, part 4, 305–317, 1952.

Analysis is given for the calculation of travel times of Love waves. The focus may be in the upper or lower layer. Some numerical results are given. H. G. Hopkins, USA

1339. Unoki, S., and Nakano, M., On the Cauchy-Poisson waves caused by the eruption of a submarine volcano (1st paper), *Oceanogr. Mag.* **4**, 4, 119–141, Mar. 1953.

Tsunami waves produced by an eruption of a submarine volcano were recorded three times by a self-registering wave gage installed on Hachijo Island about 130 km distant from the volcano. The period of the tsunami waves was about 95 sec at the beginning and, an hour later, about 30 sec, gradually decreasing with the lapse of time. The variation of the wave height was also conspicuous, showing a distinct "beat" phenomenon. Solving the Cauchy-Poisson wave problem for the case when an initial impulse or an initial elevation is given to a finite area, and comparing the theory with observations, it was found that the agreement is excellent in the period, variation of wave height, and interference phenomenon. Thus it was made clear that the Cauchy-Poisson wave can actually exist in the ocean, with its form almost the same as the theory demands. Moreover, the intensity and scale of the eruption were estimated from the comparison of theory and observations. From authors' summary

1340. Picard, L., Outline on groundwater geology in arid regions, *Bull. Res. Counc. Israel* **2**, 4, 358–371, Mar. 1953.

1341. Koning, L. P. G., Preliminary note on the frequency-depth relation of earthquakes, *Proc. k. Ned. Akad. Wet.* (*B*) **56**, 3, 301–302, May/June 1953.

Lubrication; Bearings; Wear

(See also Revs. 1013, 1016)

1342. Wilcock, D. F., The hydrodynamic pocket bearing, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-83, 18 pp.

Externally pressurized pocket bearings have much lower rates of power consumption than tapered-land and pivoted-shoe thrust bearings (about half that of conventional thrust bearings) when operated at high speeds, owing to reduction of area of high rates of shear. Hazards of external pressure source are avoided in new hydrodynamic pocket-bearing design. By the motion of the runner the oil is dragged out of oil groove, over pumping land, and into pocket. Pocket pressure suffices to support external load when oil leakage through clearance between lands and runner balances oil flow into pocket. Such a bearing successfully replaced a tapered-land bearing in a 500-kw steam turbine.

Advantages of pocket thrust bearing are low power loss, ability to measure thrust, ease of lubrication, ease of manufacture. Disadvantages are "zero film thickness" below limiting value of $\mu N/W$ (μ is oil viscosity, N shaft speed, W gross thrust load), limited flat land area for carrying load at low speed, sensitivity to misalignment. Under "ultra-high-speed conditions," centrifugal effect upon oil outflow from bearing requires study, and effects of turbulence in the pockets will become pronounced. Desirability of experimental determination of optimum pocket depth is mentioned. R. Schnurmann, England

1343. Kettleborough, C. F., The stepped thrust bearing—A solution by relaxation methods, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-9, 6 pp.

Lord Rayleigh had demonstrated the larger load capacity of a stepped slider compared to that of a tilting pad. In his calculation, side leakage was disregarded. More recently, Archibald dealt with the same problem using no such neglect. He expressed the pressure as a summation of a trigonometrical series. Like Rayleigh, he considered a pad possessing a step which courses perpendicular to the motion along the whole width. He conjectured that a pad with completely internal step would exhibit a reduced side leakage and, therefore, a higher load capacity; but he did not perform calculations referring to this.

Author, using the relaxation method, undertakes this in the present paper. In his method the pad is covered with a grid and the derivatives of pressure in Reynolds equation and the boundary conditions are approximately expressed in sums of the pressure values in the mesh points. By these manipulations the solution of the differential equation is reduced to solving a system of linear equations. The boundary conditions ensue from the demands that the pressure must vanish along the pad edges and that

the rate of flow must be the same on both sides of the step. In the afore-mentioned way, author first treated the same problem as Archibald, namely, a pad with a step coursing along the whole width perpendicular to the motion. The good agreement of his result with that of Archibald is a proof for the applicability of the relaxation method. Then author deals with a pad possessing a step which courses in the pad center perpendicular to the motion and turns on both sides to the inlet edge. Whereas the first examined pad shows, contrary to a tilting pad, only a load capacity increased by 1%, the increase in the case of the second pad amounts to 58%, due to the reduced side leakage. This confirms Archibald's conjecture. The friction force is increased in the first case by 18.4% and in the second case by 28%.

Finally, author calculates a stepped thrust bearing with 6 sector pads possessing semicircular steps. The load capacity of such a bearing is four times that of an equivalent conventional tilting-sector-pad bearing. U. Rost, Germany

1344. DeArdo, A. J., and Kipp, E. M., Observations on some factors affecting Timken data for EP lubricants, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-39, 3 pp.

The paper reports results of an investigation of variations in rubbing speed and viscosity variables when using the Timken machine for evaluation of EP lubricants.

From authors' summary

1345. Baumeister, G., Precision ball bearings (in German), *Feinwerktech.* **57,** 8, 236–241, Aug. 1953.

1346. Levinsohn, M., and Reynolds, N. E., 3rd, Experiments with water-lubricated tapered-land thrust bearings, *Trans. ASME* **75,** 6, 1137–1145, Aug. 1953.

See AMR 6, Rev. 2665.

1347. Brophy, J. E., and Romans, J. B., The lubrication of gyroscopes, *Trans. ASME* **75,** 6, 1147–1152, Aug. 1953.

See AMR 6, Rev. 2382.

1348. Charnes, A., Saibel, E., and Ying, A. S. C., On the solution of the Reynolds equation for slider-bearing lubrication—V. The sector thrust bearing, *Trans. ASME* **75,** 6, 1125–1132, Aug. 1953.

See AMR 6, Rev. 2967.

1349. Poritsky, H., Contribution to the theory of oil whip, *Trans. ASME* **75,** 6, 1153–1158, Aug. 1953.

See AMR 6, Rev. 3281.

1350. Bearings, lubricants, and lubrication. A digest of 1952 literature, *Mech. Engng., N. Y.* **75,** 10, 801–808, Oct. 1953.

1351. Fortrat, M. R., Lubrication with solid "lubricants" (in French), *Helv. phys. Acta* **26,** 3/4, 191–198, 1953.

Static and kinetic friction was measured for steel/steel, brass/steel, and aluminum/steel surfaces lubricated with colophony, beeswax, graphite, and talc. Test results indicate that with the first two lubricants static friction was greater than kinetic friction, and that with the others the reverse was true.

H. Blok, Holland

Marine Engineering Problems

(See Revs. 1254, 1256)

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